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NATIONAL ASSESSMENT OF THE URBAN PARTICULATE PROBLEM

Volume V - Baltimore

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This document is one volume of a sixteen-volume report presenting an overall assessment of the particulate problem, which was conducted by GCA/Technology Division for EPA.

This particular document is one of fourteen single-area volumes that provide working summaries of data gathered in the fourteen urban areas studied. These city reports primarily provide documentation and background information for Volume I of the study - National Assessment of the Particulate Problem - Final Report. Volume I should be considered the primary output of the report.

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NATIONAL ASSESSMENT OF THE URBAN PARTICULATE PROBLEM

Volume V

Baltimore, Maryland

FINAL REPORT

by

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Research Triangle Park, North Carolina 27711

June 1976

This final report was furnished to the Environmental Protection Agency by the OCA/Technology Division in fulfillment of the requirements under Contract No. 68-02-1376, Task Order No. 18. The contents of this report are reproduced herein as received from the contractor. The opinions, findings, and conclusions are those of the authors and not necessarily those of the Environmental Protection Agency.

FOREWORD

This document is part of a 16-volume report assessing the urban particulate problem, which was conducted by GCA/Technology Division for EPA.

This particular document is one of the 14 single city volumes that provide working summaries of data gathered in the 14 urban areas during 1974 to support an assessment of the general nature and extent of the TSP problem nationwide. No attempt was made to perform detailed or extensive analyses in each urban area. Rather, the city reports are intended as a collection of pertinent data which collectively form a profile of each urban area. This, in turn contributes to a comparative analysis of data among the 14 areas in an attempt to identify general patterns and factors relating to attainment of the TSP problem nationwide. Such an analysis has been made in Volume I of the study-National Assessment of the Urban Particulate Problem-National Assessment. The reader is referred to this volume as the summary document where the data is collectively analyzed.

This and the other 13 city reports are viewed primarily as working documents; thus, no effort was made to incorporate all the reviewer's comments into the text of the report. The comments were, however, considered during the preparation of Volume I and are included herein in order to alert the reader to different points of view. The 16 volumes comprising the overall study are as follows:

Volume	I - National Assessment of the Urban Particulate Problem
Volume	II - Particle Characterization
Volume	III - Denver
Volume	IV - Birmingham
Volume	V - Baltimore
Volume	VI - Philadelphia
Volume	VII - Chattanooga
Volume	IX - Oklahoma City
Volume	X - Seattle
Volume	XI - Cincinnati
Volume	XII - Cleveland
Volume	XIII - San Francisco
Volume	XIV - Miami
Volume	XV - St. Louis
Volume	XVI - Providence

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EXECUTIVE SUMMARY

AIR QUALITY LEVELS AND TRENDS

Geometric mean TSP concentrations in the Baltimore AQCR in 1974 range from less than 50 $\mu g/m^3$ at the monitors furthest from the city to over 100 $\mu g/m^3$ in the center city and industrial areas. Nine of the sampling sites exceed the national annual primary standard and five more exceed the secondary standard; the 24-hour primary standard was exceeded on 0.9 percent of the sampling days and the secondary standard on 7.6 percent of the sampling days. Air quality has been improving since the 1960's - arithmetic mean TSP concentrations have decreased 30 $\mu g/m^3$ at some sites near the city to 70 $\mu g/m^3$ at sites in or near the city. An average decrease of 20 $\mu g/m^3$ has occurred since 1970.

Many of the sampling sites in the AQCR, especially in and near Baltimore City, exceeded the annual standards for TSP in the past due to the high degree of urban and industrial activity. Many sites have experienced decreases in TSP concentrations because of fuel switching, decreases in fossil fuel consumption, stringent regulations, and rigorous enforcement of the regulations, and industrial emissions controls. Almost half of the sampling sites, however, continue to exceed the annual standards. Particulate emissions from urban activities such as space heating, construction, traffic, and fugitive sources have not been controlled and are becoming a more important portion of the urban TSP concentration in Baltimore as other sources are controlled.

REGIONAL SETTING

The Baltimore AQCR lies in the central portion of the State of Maryland along the western edge of the northern section of Chesapeake Bay. The important features of the AQCR are the Bay, the generally flat, low eastern portion, and the rolling hills and somewhat higher elevations of the western portion. The region lies near the path of low pressure systems which move across the country, resulting in changeable winds and weather in the region. During the summer, the region is influenced by the Bermuda High which brings a circulation of air masses over the area from the Deep South. Precipitation occurs frequently and moderately, averaging about 40 inches per year. Temperatures are moderated by the proximity to the Bay. High relative humidities are caused by the inflow of southerly winds and the proximity of the Bay. The region frequently experiences short-term inversions.

There is a high level and a wide variety of heavy industrial activity, much of which is concentrated along the Patapsco River. An extensive program of urban renewal and highway construction is being conducted.

METEOROLOGY

Patterns in annual TSP concentrations tend to follow patterns in annual rainfall but this is not conclusive. The number of heating degree days per season has been below average for 1970 to 1974, probably resulting in a decrease in fuel consumption for space heating. Transport of TSP into the area occurs when winds from the Bermuda High pass over the Deep South and through the AQCR. Some local transport, from urban and industrial areas, also occurs. Stagnating meteorological conditions of relatively short duration occasionally occur during the fall and winter seasons but are not considered important with respect to overall or annual TSP concentrations.

NETWORK DESIGN AND MONITOR SITING

The overall set of sampling sites located throughout the AQCR adequately represents the various regions within the state, with particular attention placed on populated areas and areas in the AQCR where the national standards are being violated. The specific siting of the monitors is also adequate - exposure is good; height falls within the range of 15 to 30 feet. In several cases a boiler stack on the roof of the building is a possible local source.

URBAN ACTIVITY FACTORS

Extensive programs of urban renewal and highway construction have been occurring over the past 10 years in Baltimore City. The activities involved in these programs contribute to the TSP concentrations in the city but how much is not certain. Trends in construction activity do not seem to be matched by trends in air quality at the sampling sites nearest the activity. Construction activity, then, appears to have more of an areawide effect on TSP concentrations.

There is a strong relationship between annual TSP concentrations and the predominant land use surrounding the monitoring sites. The amount and type of urban activity surrounding a site - residential, commercial, and industrial - helps to determine the TSP concentrations experienced.

REGULATIONS AND COMPLIANCE

The Baltimore AQCR regulations are considered to be stringent, especially the regulation which prohibits visible emissions. Surveillance and enforcement of the regulations has been rigorous - most of the point sources are in compliance or are under a plan for compliance within the next few years. As a result, a large proportion of the industries are achieving maximum reductions of potential emissions with respect to currently available control technologies.

EMISSIONS

Baltimore is a highly industrialized city with numerous fugitive dust sources associated with the industrial areas and with construction activities. The important sources of particulates in Baltimore are fugitive sources, industry, mobile sources, municipal refuse incinerators and space heating, although the inventories of fugitive emissions are not adequate to firmly quantify their relative contributions. Space heating and construction activity also contribute to the urban TSP concentrations. The monitoring sites located in or near the industrial and center city areas have consistently recorded the highest TSP concentrations.

Considerable decreases in particulate emissions from point sources have occurred since 1970, the largest changes occurring in the steel, cement and concrete, and power industries, and large institutions, due to emissions controls and fuel switching.

REVIEWERS' COMMENTS

The draft report for each city was submitted to interested EPA, state and local officials for comment on the contents and findings. Comments of an editorial nature were reconciled; comments of a substantive nature which reflect differences of opinion were compiled and are presented below.

Page 4 - Baltimore had a smoke program prior to 1960.

Page 9 - The city had more than one monitoring site prior to 1969.

Page 14 - Given the lack of confidence that the contractor has expressed in the fugitive dust emission calculations and the data base, there should be no quantification of these emissions in the report.

Page 30 - There is also a 0.03 gr/scf regulation that applies to all processes.

SECTION I

INTRODUCTION

NATURE OF THE AREA

The Baltimore AQCR includes the City of Baltimore and the counties of Anne Arundel, Baltimore, Carroll, Harford, and Howard, along the northwestern edge of Chesapeake Bay. Baltimore is the seventh largest city in the U.S., and is a major manufacturing area and shipping port. Air pollution control responsibility is shared by the State Department of Health and Mental Hygiene and the several local Health Departments.

Topography and Climatology

The western portion of the Baltimore AQCR lies in the Piedmont Plateau with the elevation rising gradually to the gently rolling areas of Carroll and Howard Counties and reaching 1,000 feet. The eastern portion, lying within the Middle Atlantic Coastal Plain, is generally flat, with elevations of less than 500 feet. The topography generally permits free air movement and has little effect on air pollution levels.

The Region lies about midway between the rigorous climates of the north and the mild climates of the south, and adjacent to the modifying influences of the Chesapeake Bay and Atlantic Ocean to the east and the Appalachian Mountains to the west. The net effect of the mountains and the Bay and Ocean is to produce a more equable climate compared with other continental locations farther inland at the same latitude. January is the coldest month, and July the warmest, averaging 33 degrees and 77 degrees

respectively. Rainfall distribution throughout the year is rather uniform; however, the greatest intensities are confined to the summer and early fall months, the season for hurricanes and severe thunderstorms. An average of 7 days annually produce snowfalls greater than 0.1 inch. The region averages 1,230 cooling degree days and 4,810 heating degree days each year. Since this region is near the average path of the low pressure systems which move across the country, changes in wind direction are frequent and contribute to the changeable character of the weather. Winter and spring months have the highest average windspeeds.

In summer, the area is under the influence of the large semipermanent high pressure system centered over the Atlantic Ocean near 30° north latitude. This high pressure system, commonly known as the Bermuda High, brings a circulation of warm humid air masses over the area from the deep south. The proximity of large water areas and the inflow of southerly winds also contribute to high relative humidities during much of the year.

Meteorological conditions conducive to the accumulation of air pollutants can and do occur in the Baltimore Metropolitan Area. Although topography does not materially restrict free flow of air throughout the area, adverse vertical mixing conditions involving light winds and a stable temperature lapse rate occasionally increase the concentrations of air pollution. Weather bureau data indicate that inversion conditions occur on a short-term basis about 34 percent of the time in the region. Over a 10-year interval, the region averaged 1.5 times per year when stagnations occurred that averaged 4.8 days duration. During the same 10-year period, the region experienced three cases of stagnation that lasted for 7 or more days. In general, however, Holzworth's calculations of annual normalized pollutant concentrations for the contiguous U.S., based on mixing heights and average wind speeds, indicate that Baltimore is among the cities most favorably located with respect to pollution potential.

Land Use, Employment and Population Patterns

Of the state's 3,922,000 people, over half (2,070,700) live in the metropolitan Baltimore area. The population of the region increased 19 percent between 1960 and 1970, although the City of Baltimore lost 4 percent in population.

Baltimore is one of the major industrial centers of the nation. In the metropolitan Baltimore area, slightly more than one-quarter of the working force are employed in manufacturing - see Table 1. Other major employment categories are services and retail trade.

Table 1. EMPLOYMENT BY MAJOR INDUSTRY 1970

		% of total
Agriculture	5,700	0.7
Construction	48,300	5.6
Manufacturing	203,700	23.4
Trans, comm, pub util.	59,300	6.8
Wholesale	41,200	4.7
Retail	156,360	18.0
Finance, insurance, real estate	45,900	5.3
Services	191,100	21.9
Government	118,700	13.6
	869,800	100.0

Source: Baltimore Transportation Control Plan

Industry and manufacturing in Baltimore are diversified. The leading manufacturing industries include iron and steel products, sugar refining, meat packing, metal containers, machinery, shipbuilding, automobile

assembly, clothing, petroleum refining, fertilizers, vegetable canning, bakery products, copper refining, stamped metal products, electronic and communications equipment, rockets and missiles, printing and publishing. The port of Baltimore is ranked third in foreign tonnage and annually handles approximately 50 million tons of foreign and intercoastal commerce.

Air Pollution Control

Air pollution control programs have been operational since the early 1960's in the Baltimore City Bureau of Industrial Hygiene and the Health Departments of Baltimore and Anne Arundel Counties. These local programs currently share control responsibility with the Bureau of Air Quality control of the State Department of Health and Mental Hygiene. Under a written understanding, the State and local agencies have developed what is considered to be an efficient well-organized joint control program. The control regulations applicable to particulates in the Baltimore area are quite stringent and enforcement is widely considered to be strict.

AIR QUALITY SUMMARY

Sampling for suspended particulates in the Baltimore Intrastate Air Quality Control Region takes place at 38 sites. The State Bureau of Air Quality Control operates 16 of the sites, the Baltimore City Bureau of Industrial Hygiene operated six, Anne Arundel County seven, and nine are operated by Baltimore County. The location of the sampling sites, with identifying codes, is shown for the AQCR in Figure 1 and for Baltimore City in Figure 2. Most of the sites are in suburban locations, six are considered center city, and three are rural. The height about ground of the monitors varies from near ground level (6 feet) to 50 feet, with the majority in the 20 to 30 foot range.

The 1974 annual geometric means for TSP are shown at their respective sampling sites in Figure 3 for AQCR and Figure 4 for the metropolitan area.

Figure 1. Locations of sampling sites in the Baltimore AQCR

Figure 2. Locations of sampling sites in the Baltimore Metropolitan Area

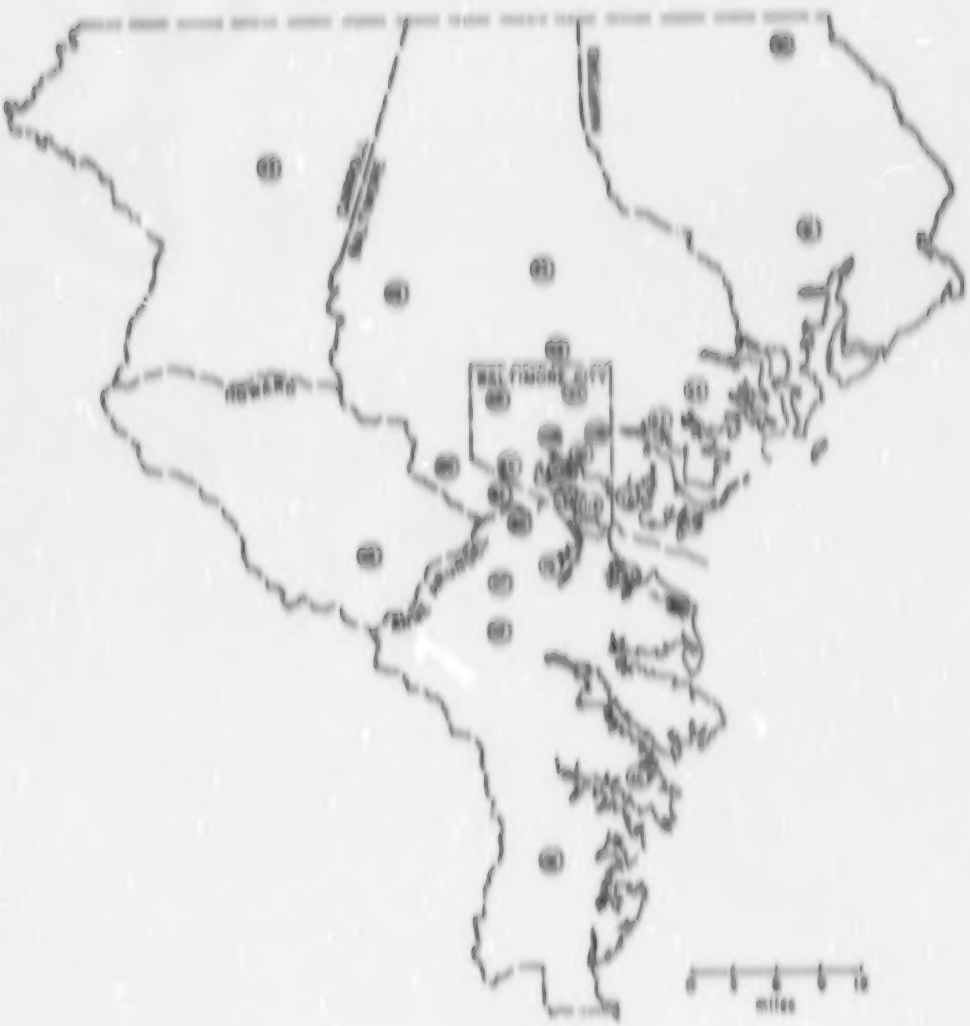

Figure 1. 1974 Annual geometric TSP means for the Baltimore AQCR

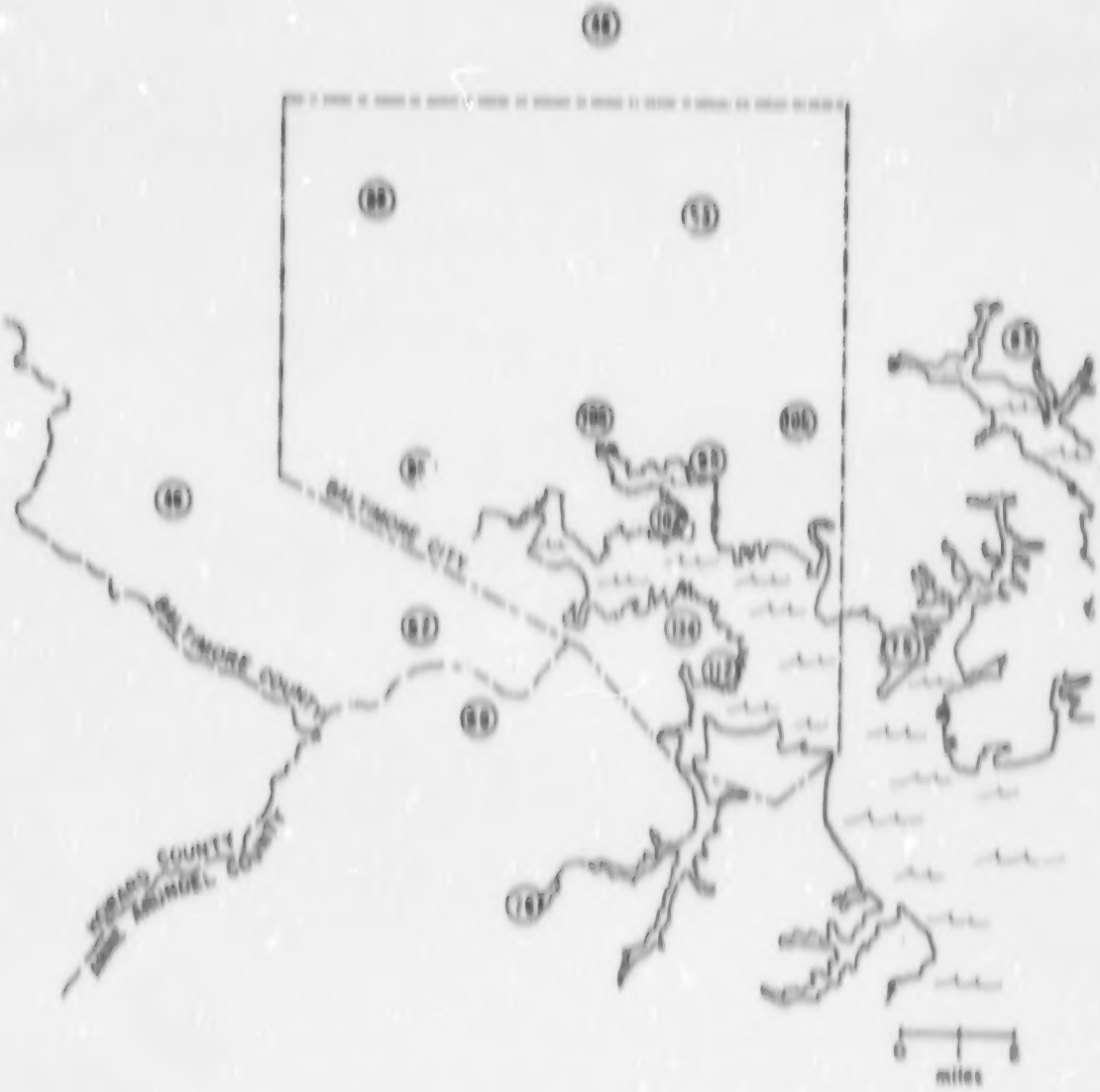

Figure 4. 1974 Annual geometric Trip means for the Baltimore Metropolitan Area

The general pattern of particulate concentrations in the AQCR is concentric around Baltimore City. The monitors furthest from the city (sites 1, 3, 6, 21, 29, 30, 31, and 32) generally recorded annual geometric mean TSP concentrations in 1974 of less than 60 $\mu g/m^3$, while levels exceeded 100 $\mu g/m^3$ at five locations within the city (sites 7, 8, 11, 17 and 19).

Of the 29 monitors recording TSP in the AQCR in 1974, nine sites exceeded the national annual primary standard of 75 $\mu g/m^3$, and five other sites exceeded only the annual secondary standard of 60 $\mu g/m^3$. Out of a total of 2,025 days of sampling, the 24-hour secondary standard was exceeded on 154 days (7.6 percent) and the primary standard was exceeded on 18 days (0.9 percent). Only eight of the 29 stations did not exceed either 24-hour standard during the year. All but two of the nine sites exceeding the annual primary standard are located in Baltimore City.

Eight of the hi-vol sampling stations were operated prior to 1969 - seven in suburban areas and one in center city Baltimore (site 7). The annual arithmetic means for these stations are plotted in Figure 5 to indicate historical trends in particulate levels. Most of the sites have shown an overall decrease in TSP levels despite some wide fluctuations from year to year. The largest decreases, of 50 to 70 $\mu g/m^3$, occurred at sites in or near the city (7, 14, and 34), while noticeable decreases of 30 to 40 $\mu g/m^3$ occurred at two other sites (4 and 27) near the city. The remaining sites (29, 32, and 33) are distant from the city and appear mainly to be fluctuating over time around some mean.

Trends in annual arithmetic mean TSP concentrations at all the sites, including those with only recent data, are included in the Appendix as Figures A-1 through A-6, grouped according to geographic areas. The TSP concentrations for the sites in a particular area tend to be close and to vary similarly, with a few exceptions due to local variations. Most of the sampling sites appear to exceed the annual standards in the past. Since only arithmetic means are available prior to 1972, the sampling

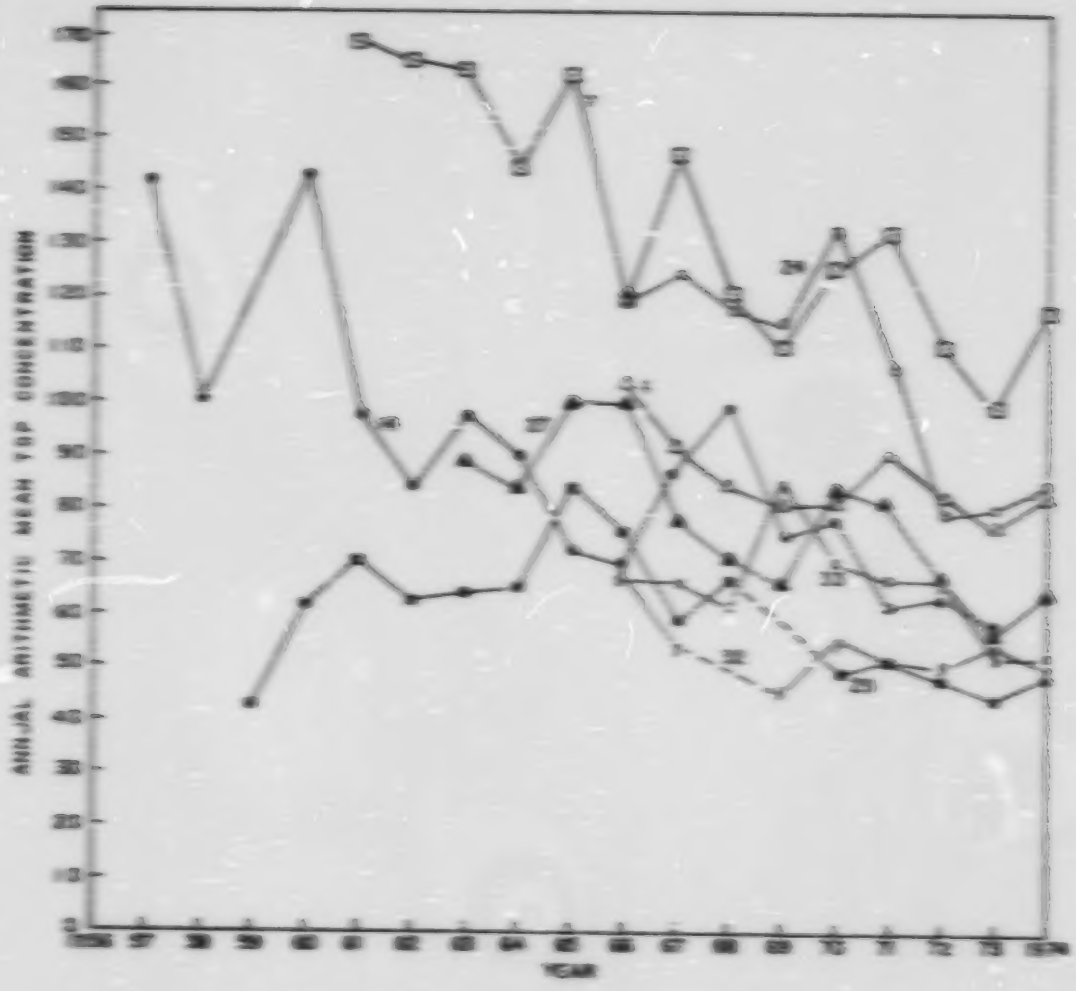

Figure 5. Historical trends in TSP levels

sites were assumed to be exceeding the annual standards if their arithmetic mean concentration was appreciably higher than the geometric means used as standards. Most of the sites in the AQCR have experienced recent decreases in mean TSP concentrations, but many continue to exceed the annual standards.

SECTION II

ANALYSIS

This section of the report considers the information available in each of several areas - sources and emissions, regulations, meteorology, etc. - that might reasonably be expected to have significant influence on ambient TSP levels.

SOURCES AND EMISSIONS

The emissions inventory maintained by the state control program provides 1974 point source emission estimates of about 37,000 and 10,000 tons/years for the AQCR and for Baltimore City, respectively (see Table 2), and an area source emissions estimate of 4,000 tons/year for the city (see Table 3). The industrial nature of the Baltimore area is apparent; industrial space heating and process emissions together account for about half of the point source emissions in the entire AQCR as well as in the city.

The above inventory does not include estimates of what have come to be called fugitive emissions, other than the estimate of construction emissions that is included in the "Nonautomotive" category of Table 3. Estimates of emissions from such sources, from a study which provides estimates on a county-by-county basis for the entire country, are summarized in Table 4. It is apparent that the estimates in Table 4 are dramatically out of line with those in Tables 2 and 3. There is an obvious large discrepancy between the two estimates of construction emissions in Baltimore City - 19320 TPY from the EPA/MRI study (Table 4) and

Table 8. STATE ESTIMATES OF 1974 TSP EMISSIONS (tons/year)

	Baltimore AQCR	Baltimore city	% of AQCR	% of city
Space heating (total)	5276	1850	15%	19%
Residential	3054	851	8%	9%
Commercial	324	108	1%	1%
Govt. institutional	959	293	3%	3%
Industry	4037	604	3%	16%
Power Plants	3204	490	9%	5%
Mobile Sources	8589	2956	23%	30%
Process (total)	17041	2088	46%	21%
Industry	16997	2060	46%	21%
Commercial	44	28		
Refuse (total)	2731	2358	7%	24%
Incinerator	2608	2358	7%	24%
Open Burning	113	0		0%
Total	36809	9942	100%	100%

Source: BAQC, Emissions for the Grant program

Table 9. AREA SOURCE EMISSIONS OF TSP IN BALTIMORE CITY, 1974

	Emissions (TPY)	% of total area source emissions
Nonautomotive[a]	1,178	31%
Residential space heating	871	23%
Mobile source[b]	1,778	46%
Total:	3,828	100%

Source: BAQC

[a]Nonautomotive includes boats, ships, agriculture, construction, trucks, aircraft, miscellaneous gas engines and fires.

[b]Mobile refers to automobiles.

1,372 TPY from the Bureau of Air Quality Control (Table 3). Neither estimate of construction emissions seems to be reasonable. There are no estimates of other types of fugitive emissions from the Bureau of Air Quality Control that could be compared with the figures from the MRI study, but it appears that the estimates of the latter are excessively high. In fact, the Emissions Inventory of Agricultural Tilling, Unpaved Roads and Airstrips, and Construction Sites states that the estimated relative error is ± 30 percent for construction emissions and ± 20 percent for unpaved roads emissions. It appears obvious, then, that the estimates of fugitive emissions are inadequate and should be verified before firm conclusions can be drawn. Generally, however, it seems reasonable to believe that total emissions should be increased somewhat by fugitive source estimates, but not in the magnitude of Table 4.

Table 4. ESTIMATES OF FUGITIVE SOURCE EMISSIONS (tons/year)

	Baltimore AQCR	Baltimore City
Unpaved roads	406,510	510
Dirt air strips	17	0
Construction	122,760	19,320
Land tilling	1,510	0
Total	530,77	19,830

Source: Emissions Inventory of Agricultural Tilling, Unpaved Roads and Airstrips, and Construction Sites, Environmental Protection Agency Publication No. EPA-450/3-76-085, November 1976.

Emissions inventories of point sources in the Baltimore Metropolitan Area were compiled for 1970, 1973, and 1974 and changes in emissions over time are shown in Table 5. The largest average net changes in emissions from 1970 to 1974 occurred in the steel, cement and concrete, and power generation industries, and in large institutions. The decreases

Table 5. CHANGES IN POINT SOURCE EMISSIONS IN THE BALTIMORE METROPOLITAN AREA, 1970 TO 1974

Type of industry	Number	1970 emissions	1974 emissions	Average net change	Net change
Steel	4	46,712	39,567	-1,786	-7,144
Cement/concrete	3	1,765	239	-763	-1,526
Minerals/sea/the	3	767	79	-230	-688
Refinery	3	1,322	198	-375	-1,124
Asphalt	1	109	15	-94	-94
Chemical	6	1,562	1,076	-81	-486
Foundry	1	36	8	-28	-28
Detergents	2	274	109	-83	-165
Shipyard	1	17	22	+5	+5
Sugar	1	123	52	-71	-71
Distillery	1	78	25	-53	-53
Power	6	5,993	1,448	-792	-4,545
Sewage	1	26	16	-10	-10
Incinerator	2	2,851	2,521	-165	-330
Institution	6	4,338	134	-700	-4,204
Gypsum	2	745	64	-341	-681
Total	42	66,708	45,563	-503	-21,145

Source: Bureau of Air Quality Control, State of Maryland

are due to sources coming into compliance with regulations by applying control devices, and to major changes in the pattern of fuel use. This latter effect is illustrated clearly in Table 6, which indicates a massive decrease in coal consumption over a decade, with a corresponding increase in the use of fuel oil and natural gas. For Baltimore City industry, coal usage declined 96 percent between 1963 and 1972, while usage of fuel oil and natural gas increased by 16 and 58 percent, respectively. This trend has also occurred with the smaller, residential heating units that are considered area sources. Table 7 indicates that residential coal consumption in Baltimore City has decreased substantially during the past 25 years. The number of dwelling units using coal decreased 81 percent and the number using oil decreased 13 percent, while the number using gas increased 37 percent. A new nuclear power plant was put into operation in 1974, thus decreasing fuel oil consumption by power plants in and around Baltimore City. In general, there has been a trend in fuel consumption toward fuels with lower particulate emissions, especially natural gas.

The geographic pattern of emissions within the area is, as would be expected, not uniform. Baltimore has a highly industrialized area where much of the industry is concentrated along the Patapsco River and the Harbor. Associated with the industrial area are fugitive dust sources such as railroad yards, materials stock piles, unpaved roads, and empty lots. As a large city, Baltimore also experiences urban activities such as space heating and traffic, which contribute to TSP emissions in a pattern generally proportional to population. In addition, the city has been undergoing an extensive program of urban renewal and highway construction. The locations and emissions of the major point sources are shown in Figure 6. Estimates of the overall emissions are shown in Table 8, as estimated from the 1974 point and area source inventories. The point source portion of the emissions is very heavily concentrated in the CBD and industrial areas, and the area sources, while also highest in the CBD, are more nearly evenly distributed; combined, the highest overall density is thus in the CBD area, with the industrial area reasonably close. Several

Table 6. FUEL USAGE BY INDUSTRY, IN BALTIMORE CITY

	1963	1972	Percent change
Coal (tons)	683,000	25,000	- 96
Fuel oil (bbl)	6,640,000	7,679,000	+ 16
Gas (10^6 ft^3)	13,000	31,000	+ 58

Table 7. FUEL USAGE BY NUMBER OF DWELLING UNITS, IN BALTIMORE CITY

	Number of dwelling units			Percentage of dwelling units		Percent change
	1950	1960	1970	1960	1970	
Gas	37,000	81,000	128,000	30	47	+ 37
Oil	136,000	164,000	142,000	61	52	- 13
Coal	85,000	23,000	4,000	9	1	- 83
Total	258,000	268,000	274,000	100	100	+ 22

Table 8. TYPICAL EMISSIONS DENSITIES IN BALTIMORE CITY

Predominant land use	Typical emission densities TPY/square mile		
	Area source	Point source	Total
Center city	70	200	270
Industrial	15	200	215
Dense residential	35	10	45
Residential	20	0	20

Estimated from area source emissions density for Baltimore City and the 1974 point source emission inventory.

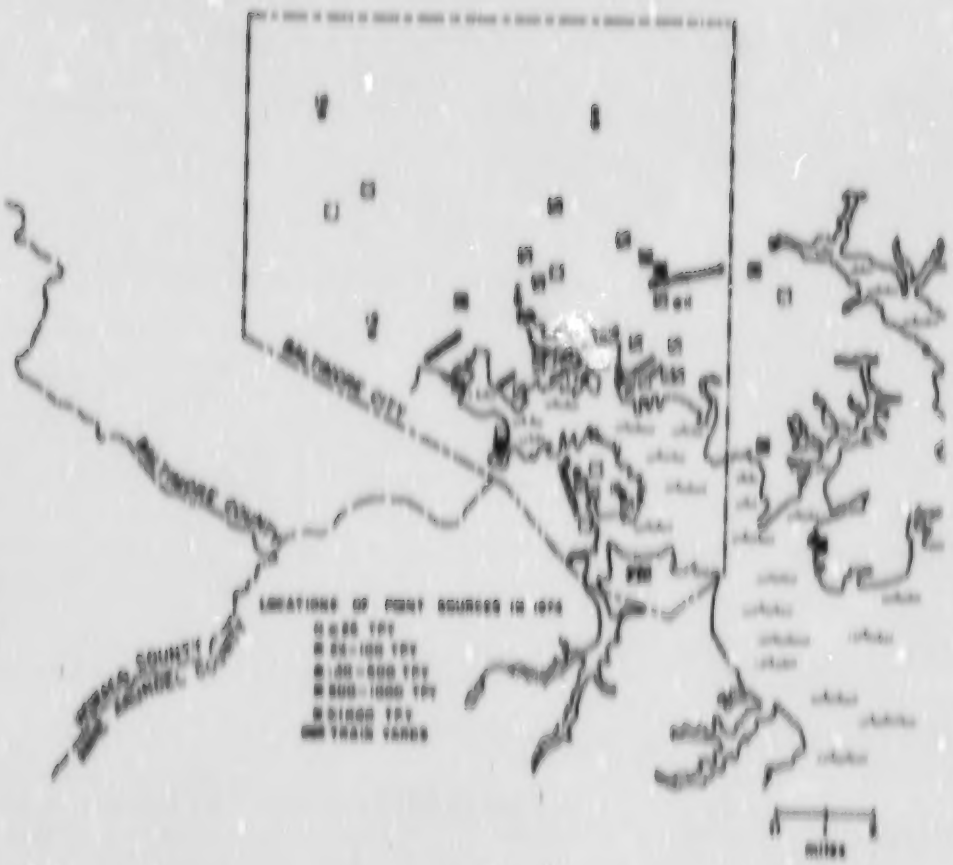

Figure 6. Locations of major point sources

of the monitoring sites – the Southeast Police Station, Fire Company 22, Fort McHenry, Fairfield, and Patapsco Sewage (sites 11, 18, 17, 8, 19) – are located near or within the center city-industrial area, and these sites have consistently had the highest TSP concentrations of the AQCR over the past several years.

METEOROLOGY AND CLIMATOLOGY

Next to the general level of pollutant emissions, the most obvious factors that can influence TSP levels are meteorological and climatological ones. In the scale of several years, the most important factors are rainfall, which can affect particulate levels in several ways, and winter heating demand, which can have an indirect influence through its effect on emissions.

Baltimore experiences frequent and moderate amounts of rainfall, averaging about 42 inches per year, spread fairly uniformly throughout the year. Trends in annual rainfall (Figure 7) tend to be matched by corresponding and opposite trends in annual TSP concentrations because rainfall tends to wash particulates from the air and to suppress dust. Lower than average amounts of rainfall fell in the years 1964 to 1965 and 1969 to 1970. The trend plots in Figure 5 show that somewhat higher TSP concentrations occurred at three of four sites in 1965, at one of seven sites in 1969, and at four of eight sites in 1970. Appreciably higher than average amounts of rainfall fell during the period 1971 to 1973, while annual TSP concentrations decreased at the same time for many of the sampling sites. But TSP concentrations do not follow precipitation trends at some of the sites during some years, so it is apparent other significant factors are also operating to influence particulate levels.

Baltimore experiences moderately cool winters, resulting in an average of 4800 heating degree days each year. Space heating, both commercial and residential and mostly by oil furnaces, is considered to be an important

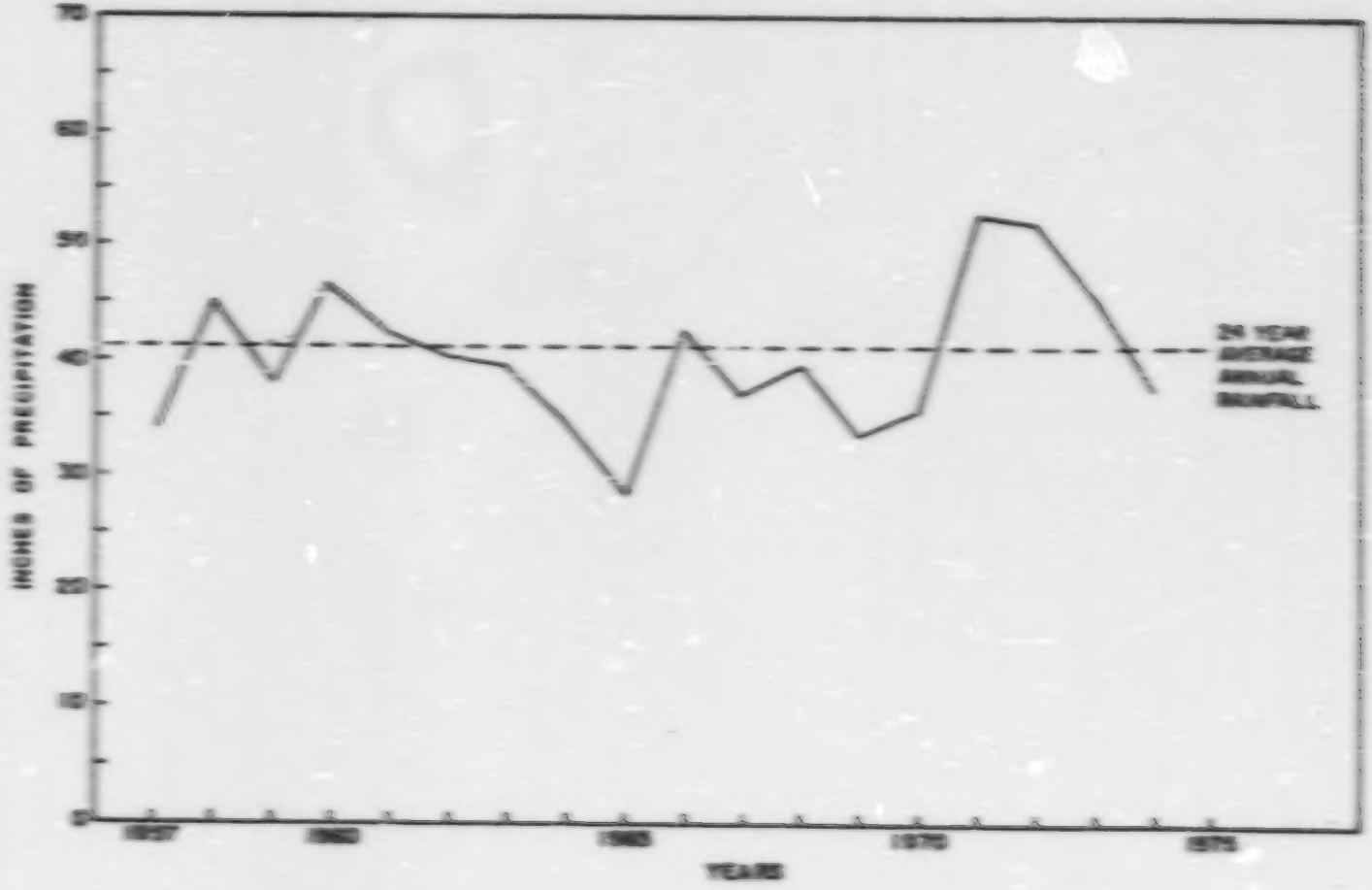

Figure 7. Annual rainfall

area source of particulates. There is a seasonal pattern in monthly mean TSP concentrations -- slightly higher monthly means occur in the winter due in part to space heating emissions (see Figure 8). The trend in the number of heating degree days per season has been downward since the winter of 1969 to 1970 -- see Figure 9. This indicates that the trend in fuel consumption for space heating is also downward which accounts in part for the downward trend in TSP concentrations noted since 1970. The energy crisis of 1973 to 1974, in addition to the mild winter that season, most likely resulted in a considerable decrease in fuel consumption by residential, commercial, and mobile sources with corresponding effects on air quality.

The meteorological patterns of the Baltimore area are responsible for the concentration and direction of TSP entering the region. Like other East Coast cities, Baltimore is affected by the Bermuda High in the summer and fall seasons. Southwesterly winds come from the back side of the high and pass over the deep south before reaching the Baltimore area and thus, tend to carry higher concentrations of particulates. On the east coast, winds from the northwest are associated with incoming cold fronts carrying fresh polar air, and winds from the east to northeast are associated with northeasterly storms. TSP concentrations tend to be lower when winds are from these directions. Figures 10 and 11 are graphs of TSP concentration as a function of wind direction for two sites fairly well away from the city; they show that TSP concentrations are higher for winds from the southwest and lower for winds from the northeast to northwest. These regional meteorological effects are generally only apparent at the sampling sites away from the city; those closer in are more likely dominated by local effects.

Graphs of TSP concentration versus wind direction show such local effects on the sampling sites. Figures 12 through 14 show local directional effects at sites near or within the city. The bars of the graphs are longer at sites nearer the metropolitan area, indicating that particulates tend

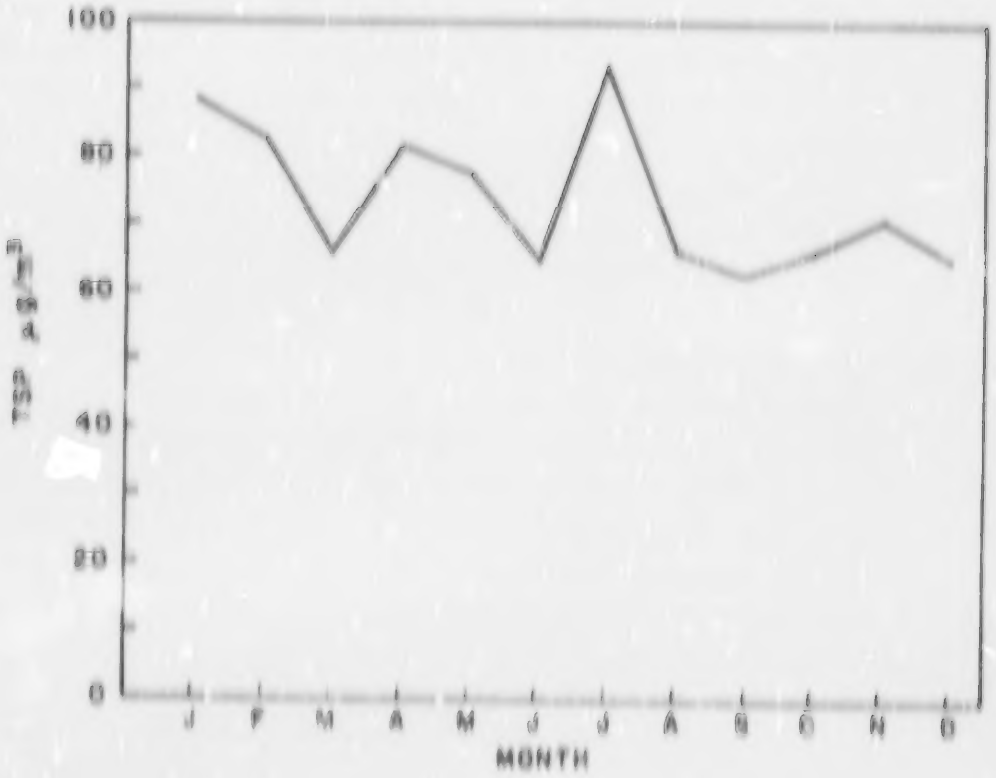

Figure 8. Monthly citywide mean TSP concentrations

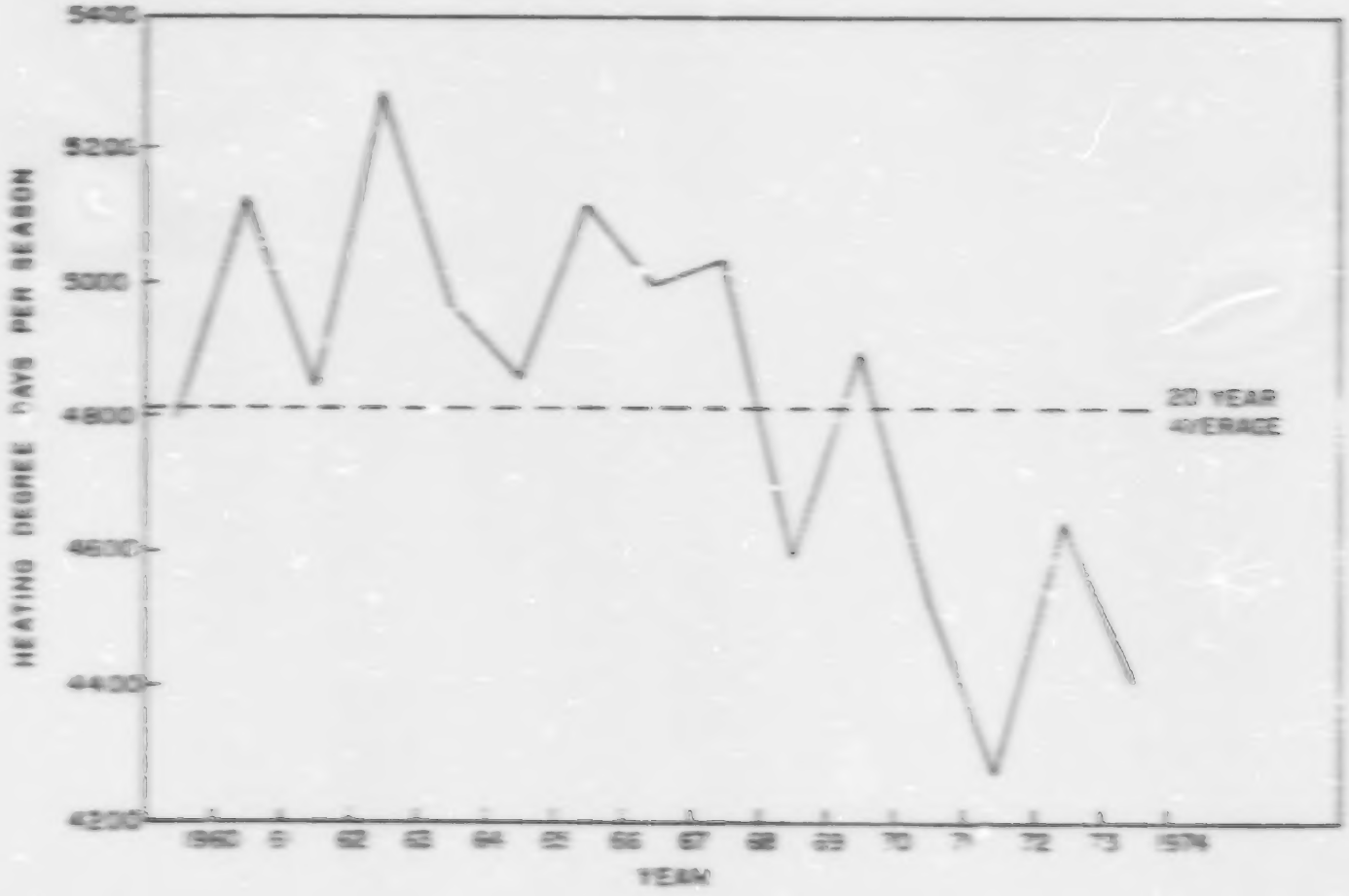

Figure 5. Heating degree days per season

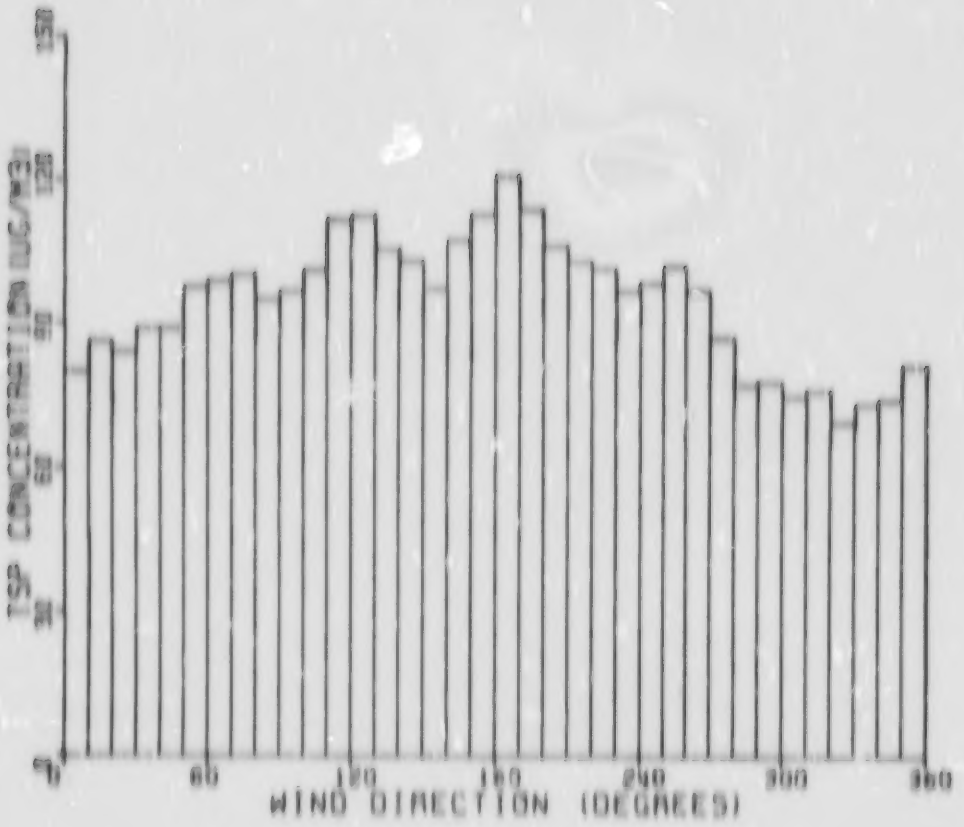

Figure 10. TSP versus wind direction, NW Police Station (site 12)

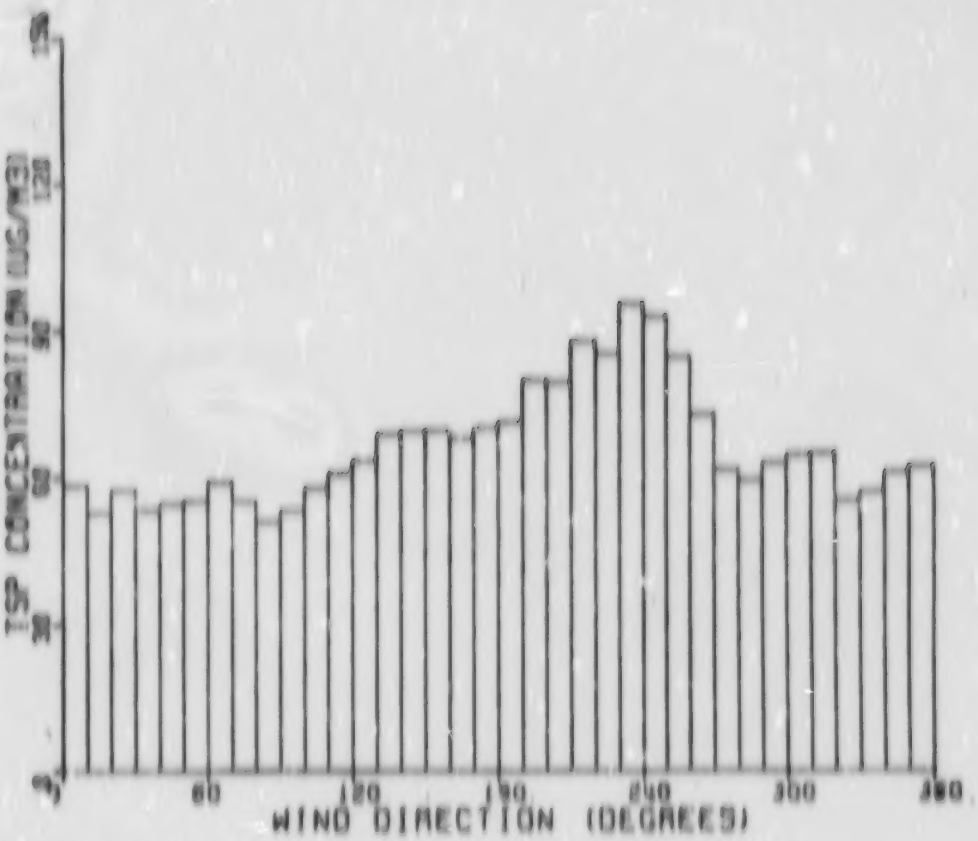

Figure 11. TSP versus wind direction, Essex (site 25)

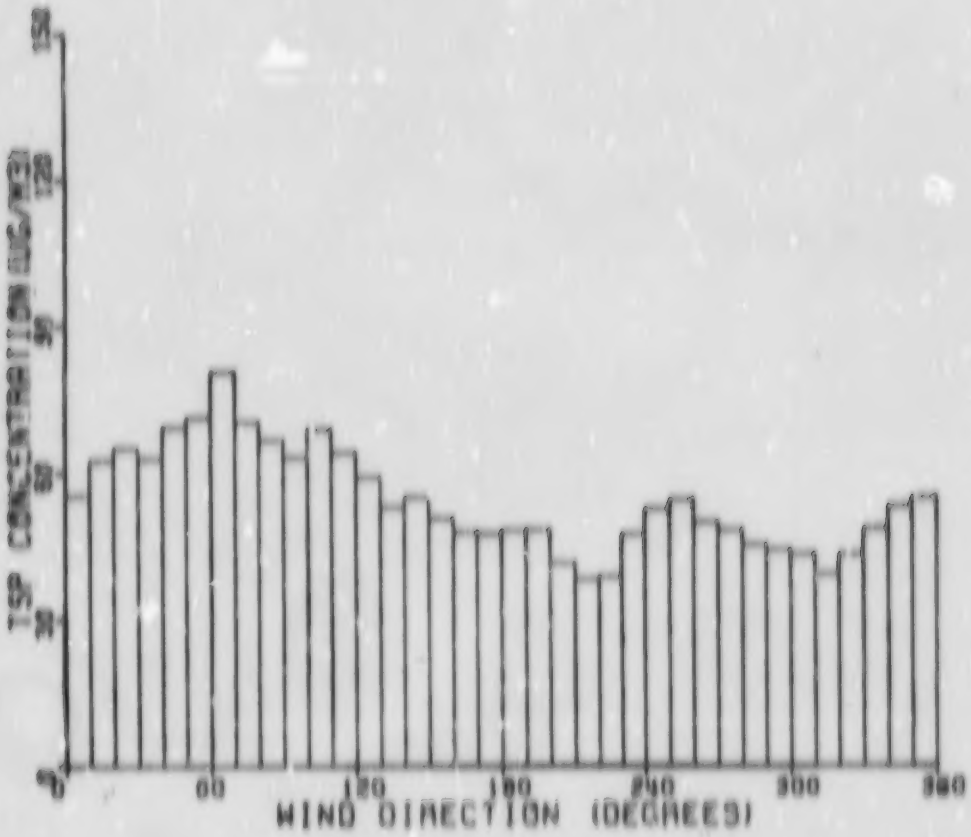

Figure 13. TSP versus wind direction, Linthicum (site 2)

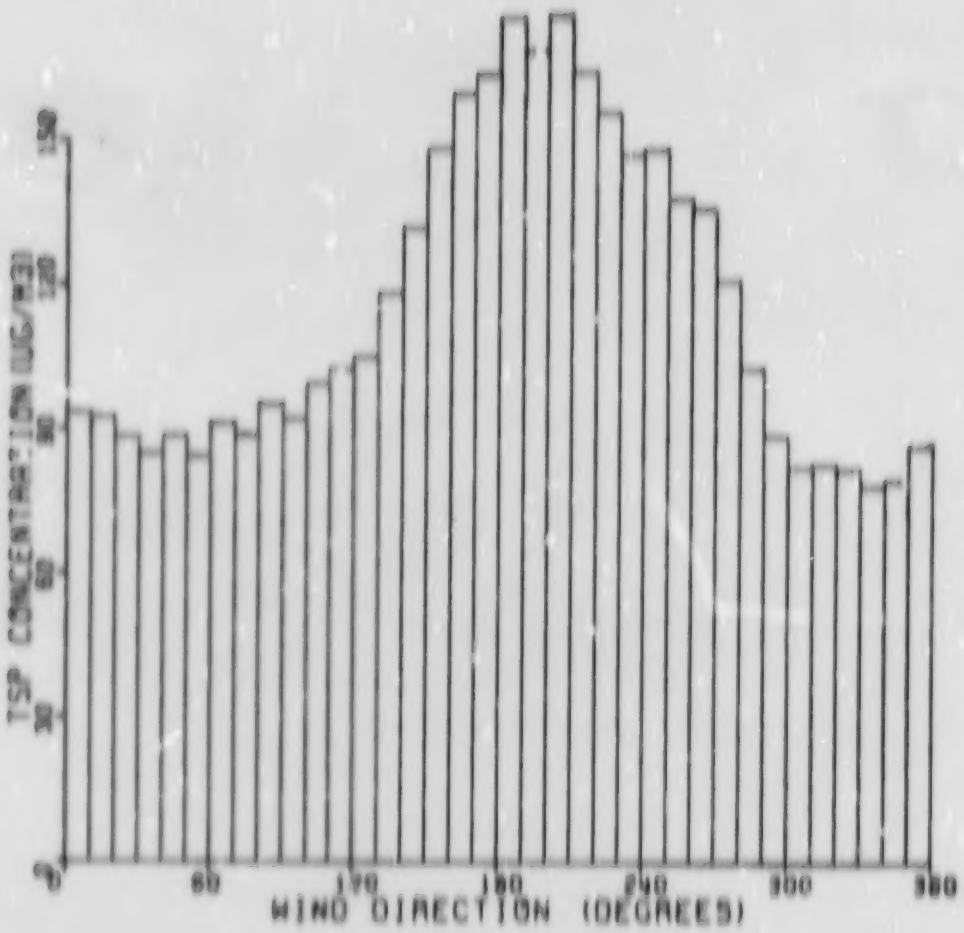

Figure 13. TSP versus wind direction, SE Police Station (site 11)

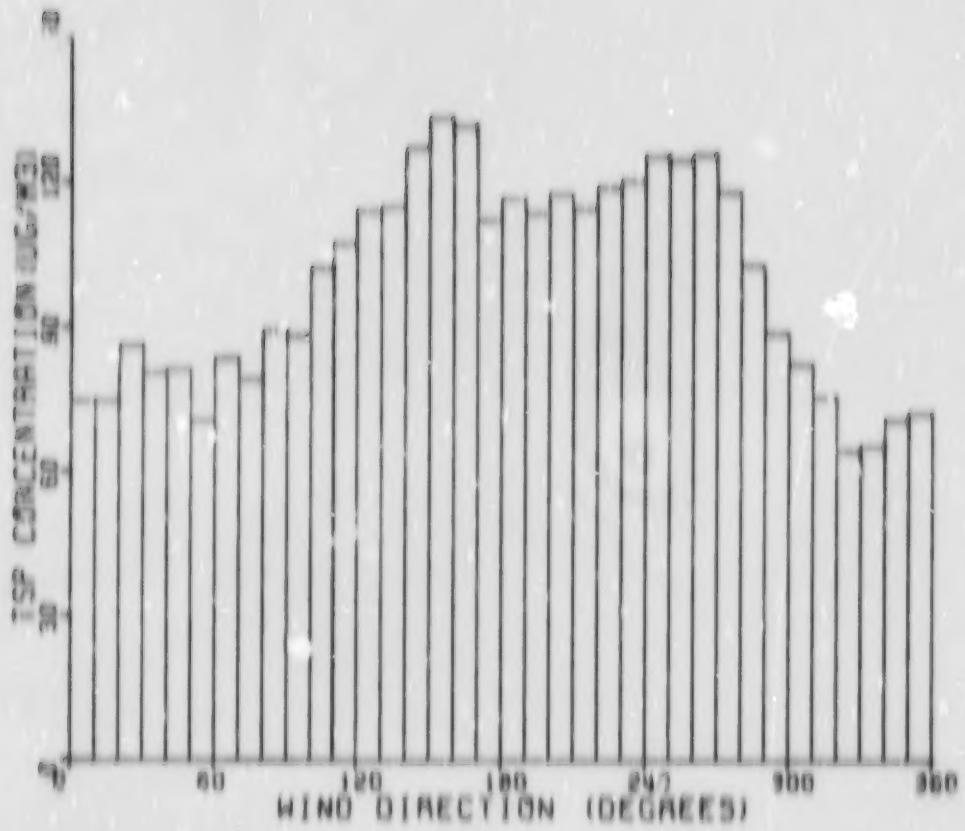

Figure 14. TSP versus wind direction, Fire Engine Co. #22 (site 18)

to be picked up in urban and suburban areas as air flows by toward the city and away from it after passing through. The longer bars in the graphs occur for the directions in which the areas of industrial concentration are located with respect to the sampling sites. The greatest TSP concentrations for site 11 occur when winds are from the southwest while the greatest concentrations at sites 12 and 18 occur with winds from the southeast and at site 2 with winds from the northeast — in each case, the direction of greatest concentration is toward the Patapsco River industrial areas.

LEGAL AUTHORITY, REGULATIONS AND SURVEILLANCE

Under the Air Quality Control Act of the State of Maryland, the Department of Health and Mental Hygiene has jurisdiction over emissions into the air, preparation of regulations for the control of air pollution, establishment of standards for emissions and ambient air quality, and enforcement of the standards. The Bureau of Air Quality Control within the health department is the administering agency for rules and regulations for the prevention and control of air pollution throughout the state where other agencies do not exist. Local health departments in Baltimore City and several counties (including Anne Arundel and Baltimore) have also accepted the responsibility of making regulations (adopting either the state regulations or more stringent ones) and enforcing them.

The air pollution control regulations for the state consist of two parts. The first part is general regulations which pertain to all areas of Maryland. The second part is additional regulations which pertain specifically to certain areas of the state, one of which is the Baltimore AQCR. The regulations dealing with particulates are summarized in the appendix.

In Baltimore City, there has been a total ban on open fires and small incinerators for several years. Open burning is allowed only in genuine emergencies, such as during recent garbage strikes and the aftermath of

a hurricane, but every possible way which avoids open burning is examined first. Baltimore County now also has a ban on open burning within the Beltway.

Residential oil burners are a large category of particulate sources that are not covered by the regulations. The Baltimore City agency recently conducted a voluntary survey of residential furnaces and discovered that 80 percent could not meet the state standards for allowable emissions from fuel combustion (Regulation No. 2) if it were to be extended to cover them. Both the city and the state agencies are cognizant of the problem and are seeking feasible ways of controlling emissions from residential oil burners. One reasonably enforceable possibility is a requirement for service contracts with the oil suppliers for the maintenance of home furnaces.

In order to understand the stringency of the Maryland and Baltimore AQCR regulations, it is necessary to compare them with the regulations of other states and AQCRs. In this report, only general comparisons are possible but more detailed comparisons will be performed later.

The visible emissions regulation of the Baltimore AQCR is among the most rigorous in the country in that it totally prohibits visible emissions. The process weight regulation is comparable to the national average of state regulations but the fuel burning emissions regulation is much more stringent, allowing less than half of the emissions allowed by most other states. The standards for the sulfur content of fuels are among the more stringent in the country -- all fuels to contain less than 1.0 percent sulfur by weight, and distillate and residual oil and process gases used as fuel to contain less than 0.3 percent, 0.5 percent, and 0.3 percent sulfur, respectively. Air quality standards for particulates are as stringent or more so than the national air quality standards -- the 24-hour standards are 140 $\mu g/m^3$ (more adverse range lower limit) and 160 $\mu g/m^3$ (serious level) as compared to 150 $\mu g/m^3$ (secondary) and 260 $\mu g/m^3$

(primary), the national 24-hour standards; the annual standards are 65 $\mu g/m^3$ (more adverse range lower limit) and 75 $\mu g/m^3$ (serious level) as compared to 60 $\mu g/m^3$ (secondary) and 75 $\mu g/m^3$ (primary), the national annual standards. There is a requirement for minimizing increases of a pollutant in the ambient air even if it is not presently exceeding the standards.

The responsibilities for surveillance of sources and enforcement of regulations are divided between the state and the local agencies, taking into account problem areas and the manpower available in each. In general, the agencies operate by putting one person in charge of the inspections and compliance plans of all plants of one industry type in a certain area. The state inspects all registered plants at least once every 3 years and major sources (over 100 TPY) at least four times a year, even if the sources are in compliance and there have been no complaints. The Baltimore City agency makes inspections once every 1 or 2 years. Registrations are checked periodically and updated when changes in processes or fuel usage result in changes in the emissions inventory.

When an industry is not in compliance with regulations and will not be able to achieve the standards before the target date for compliance, a plan for compliance is negotiated between the industry and the air pollution control agency responsible for that jurisdiction. Plans for compliance take into account the available control technology for that industry type and the economic condition of the company. All compliance plans must be approved by the Secretary of the Department of Health. Once a plan has been approved, the industry must follow the schedule of steps toward compliance set forth in the plan or it will be considered in violation of regulations.

Surveillance of sources and response to complaints are continuous activities. Both the state and Baltimore City make night inspections for visible emissions. Baltimore City uses radio-equipped cars to respond promptly, day and night, to complaints or other special needs.

Most of the point sources are in compliance or are under a plan for compliance within the next few years. There have been only a few major court cases against companies testing the applicability of the regulations. The results of the cases have generally been in favor of the air pollution control agencies. Most companies, however, have cooperated when shown the controls that industries have adopted. Exceptions have been made in hardship cases, but most companies are or will be in compliance with the regulations.

URBAN ACTIVITY FACTORS

Construction Activity

Baltimore City has been conducting a large urban renewal program over the past 10 years, resulting in a considerable amount of demolition, construction, and rehabilitation. Figure 15 shows the locations of urban renewal areas and highway construction with respect to the monitoring sites.

Urban renewal involves demolition of structures, clearing of the land, and construction of new buildings, as well as rehabilitation of older structures. Highway construction involves demolition of structures, clearing of the land, grading and paving of the highways, construction of bridges and interchanges, and grading of the median and right-of-way. All of these activities generate significant amounts of particulates. Urban renewal and highway construction have been occurring for a long time in several areas in Baltimore.

Three monitoring sites (sites 11, 12, and 24) are between three-quarters of a mile and a mile in distance from construction activity. Annual mean TSP concentrations at the three sites are all greater than the annual primary standard; however, there have been recent declines at all of the sites, which suggests that any impact from the construction has not been

Figure 15. Locations of highways, highway construction, and urban renewal

major. A fourth site, Fire Department Headquarters (site 7), is only one block away from the current location of construction on route I-83, which has been going on for the past 3 years. In addition, a considerable amount of urban renewal activity has been occurring in the central city area near the monitoring site. TSP concentrations at that site have been generally declining over a long period, and in particular decreased significantly between 1971 and 1973, in parallel with a number of other sites (see Figure 5). Levels increased significantly between 1973 and 1974, however, much more proportionately than other sites. It is believed that this represents the effect of the I-83 highway construction as it moved nearer the immediate vicinity of the Fire Department Headquarters site. Such an effect is clearly suggested by the short-term trends in TSP levels through the latter half of 1974. However, a careful separation of the effect of the construction from that of other factors requires a more elaborate statistical analysis than has been possible to date.

Overall, while it would appear reasonable that construction activity must be contributing to the areawide TSP problem, citywide trends in the amount of construction activity do not correspond to the overall trends in air quality. Considerable highway construction and urban renewal activity have been occurring over the past 3 years while TSP annual mean concentrations have been decreasing during the same time. It thus appears that a striking effect is to be seen only in the immediate vicinity of the construction. Though the high level of construction activity is not causing corresponding trends in the TSP concentrations recorded, it is presumably contributing to the high urban TSP concentrations, and is in any event increasing in relative importance as the contributions from other sources decline. Further reductions in urban TSP concentrations will probably depend to some degree on the control of particulates generated by urban renewal and highway construction activities.

Land Use and Traffic Activity

In Baltimore City, the general pattern of land use is largely dictated by the Patapsco River (see Figure 17 in Section III). Industry is concentrated along the shores of the Patapsco River in South Baltimore, Fairfield, Dundalk, and Sparrows Point. The central business district is located at the head of the northernmost portion of the river. The urban areas of the city lie around the CBD and adjacent to the industrial areas. Land use becomes increasingly suburban farther from the CBD, urban and industrial areas.

Table 9 shows the level of TSP concentrations at sampling sites in four different types of area. At the five sites where land use was predominantly industrial or center city, the 1974 geometric mean TSP concentrations averaged greater than 100 $\mu g/m^3$. Four of the residential sites are below the national annual primary standard of 75 $\mu g/m^3$. The three residential sites which exceeded the primary standard were probably influenced by the industrial areas located near them.

Table 9. TSP AND LAND USE CHARACTERISTICS

Predominant land use	Average of 1974 TSP geo. mean $\mu g/m^3$	Sampling sites
Industrial	113	8, 11, 17, 19
Central Business District	105	7
Residential-Industrial	89	12, 18, 24
Residential	61	2, 9, 10, 26

Different land uses imply different amounts and types of activities generating particulates and thus affect the particulates concentrations recorded. In Baltimore, there is a good correlation between annual TSP

concentrations in 1974 and the predominant land use surrounding the monitoring sites.

Traffic data, in the form of average daily traffic, is available for four of the city sites, the four police stations. There was no correlation apparent when ADT (per foot of distance of the monitor from the street) was compared with the 1974 mean TSP concentration but a relationship was apparent between TSP and the land use characteristics of the sites. For two of the sites, the traffic information available was taken in 1967. For another site, the street for which traffic data was available was several hundred feet from the sampling site. It is possible that the data available is not representative of the actual situations at the four police stations but it is believed to be more likely that other urban variables are more influential on TSP concentrations.

NETWORK DESIGN AND MONITOR SITING

Sampling sites are located throughout the AQCR and represent the various kinds of land development in the area. The locations of the sampling sites are shown in Figure 1 for the AQCR and Figure 2 for the metropolitan area. Coastal areas are represented by sites in Annapolis, Riviera Beach, Dundalk, and Fort Howard (sites 1, 27, 24, and 20), rural areas by Harwood and Cockeysville (sites 6 and 31), a wide variety of suburban and residential areas by Linthicum, Odenton, Glen Burnie, Harmans, Baltimore, Reisterstown, Catonsville, Essex, Middle River, Lansdowne, Westminster, Bel Air, Whiteford, Simpsonville and Towson (sites 2, 3, 4, 5, 9, 10, 14, 15, 16, 21, 22, 23, 25, 26, 29, 30, 32, 33), center city areas by sites in Baltimore (sites 7, 11, 12, 13, 18, 28), and industrial areas by Baltimore City (sites 8, 17, and 19). Industry tends to be concentrated along the Patapsco River - South Baltimore, Fairfield, Dundalk, and Sparrows Point. Information about each sampling site in the network is given in Table A-1 in the appendix.

The geographical configuration of the monitoring network in the Baltimore AQCR is adequate. The sampling sites are well spread out in the outer portions of the AQCR, becoming more numerous and closer together near and in the city, especially in the center city and industrial areas. The network seems sufficient to record the variety of air quality situations possible with different types of land development, with particular attention placed on populated areas and areas in the AQCR where the national standards are being violated.

In general, the specific siting of the hi-vol monitors is also adequate. Seven of the sampling sites in the metropolitan area were visited in order to assess hi-vol exposure and possible impacts of each site's immediate neighborhood on the TSP concentrations recorded there. These sites were assumed to be representative of the monitor siting characteristics in the AQCR, and their characteristics are summarized in Table A-2 in the appendix. The exposure of the monitors is generally good, without obstructions by the building on which the monitor is located or other surrounding buildings. The monitor at Fort McHenry receives an especially long-range exposure due to its location on a peninsula. In several cases, a boiler stack on the roof of the building is a possible local source. The heights of the monitors are also adequate, neither so low that they are affected predominantly by immediately local sources nor so high that a significant decrease in particulate concentrations might have occurred due to the height. The Fort McHenry monitor is the highest at 50 feet but its exposure is intended to be long-range. The rest are in the range of 15 to 30 feet.

SECTION III

SUMMARY AND CONCLUSIONS

SUMMARY

Air Quality Levels

Annual mean TSP concentrations in 1974 range from less than 50 $\mu g/m^3$ at the monitors furthest from the city and around 60 $\mu g/m^3$ in residential areas to over 100 $\mu g/m^3$ in the center city and industrial areas. The national annual primary standard was exceeded by nine sampling sites and the secondary standard by five sampling sites out of 39 monitors in 1974. The 24-hour primary standard was exceeded on 0.9 percent of the sampling days and the secondary standard on 7.6 percent of the sampling days.

Baltimore City is highly industrialized and densely populated and is presently undergoing a program of urban renewal and highway construction. The high degree of activity in Baltimore causes the high TSP concentrations recorded at the city sampling sites. Table 10 summarizes the land use characteristics and urban activities in the vicinity of the city sampling sites. The sites which are predominantly industrial or center city (sites 11, 17, 8, 15, and 7) recorded the highest TSP concentrations; the residential sites influenced by nearby industry (sites 24, 18, and 12) recorded somewhat lower TSP concentrations which were still above the annual primary standard; and the predominantly residential sites in and near the city (sites 9, 10, 26, and 2) experienced TSP concentrations around the annual secondary standards. General urban activity in Baltimore includes

Table 10. LAND USE CHARACTERISTICS OF SAMPLING SITES

Site number	City	Location	Site type (Res., Comm., Ind., Agric., Open)	Predominant land use	Land use
11	Baltimore	SE Yellow	Res	Residential	residential, industrial, forested; grounds surrounding Rs 2, 3 and 5 Industrial – Smelt Foundry 2, 10% within 0.5, cruise land 10% within 2 Highway construction – 1/2 within 2
17	Baltimore	Ft. Gilmore	Res	Industrial	park – Smelt Foundry 1 Res. rental – strip north & trailer south Smelt Foundry 0, Quarry trucks south & Industry 1/2 within 2, Woodlands 1 1/2 within 3
6	Baltimore	Overbrook	Res	Industrial	Industrial, surrounding, trucks south Smelt Foundry 0 and 1/2 within 3
19	Baltimore	Ferguson Off	Res	Industrial	Industrial, surrounding
4	Baltimore	SE Yellow	Res	Residential	residential & park surrounding
10	Baltimore	SE Yellow	Res	Residential	residential, surrounding national industrial
20	Cumberland	High School	Res	Residential	residential & park surrounding Industrial – 1/4 within 3
2	Cumberland	Overlook School	Res	Residential	residential, surrounding
24	Dunkirk	Calhoun St.	Res	Residential	residential, surrounding elm Industrial – Marine Terminal 3/4 within 4 to NE, Smithtown Steel & Electronic Pt., 1 within NE Highway construction – Res. 480 1/2 within 3 to NE
18	Baltimore	Elm & 1st	Res	Industrial	row industrial, surrounding elm Industrial – 1/4 within 0, 1/2 within 1, 1/2 within 3
7	Mt. Albert	Elm NE	Res	medium city	medium city surrounding park & residential – 1/4 within 0 and 2 industrial – 1/4 within 3
12	Baltimore	SE Yellow	Res	Residential	residential, surrounding park Smelt Foundry 0 industrial 1/4 within 0, 1/4 within NE highway construction

traffic, space heating, highway construction, urban renewal and other fugitive emissions, and industry and has a localized effect on sites in the industrial and center city areas which causes them to experience the highest TSP concentrations. It also has an areawide effect in that sites near the city and/or industrial areas are influenced by the activity and record high TSP concentrations.

Pollutant roses show the directional effects on a sampling site and thus indicate the sources which are contributing most to the TSP concentrations recorded at the sampling site. Figure 16 consists of pollutant roses for sampling sites around the harbor which is shown by Figure 17 to be the area of industrial development. A barb on a pollutant rose indicates the average TSP concentration at the sampling site when the wind is from the indicated direction. The longest barbs of the Baltimore pollutant roses; i.e., the greatest TSP concentrations, occur when winds at the sampling sites are from the direction of industrial development. For sites 7, 11, and 18 the direction of the longest barbs is from south to southwest; for site 12 the direction is southeast to southwest; for site 24 southeast to northwest And for site 17 west. Sites 8, 17 and 19 are surrounded by industry; as a result, all the barbs are long, meaning that high concentrations of TSP at these sites come from all directions.

Pollutant roses for sampling sites farther from the city also show directional effects (see Figures 10 and 11 for TSP concentration versus wind direction). The higher TSP concentrations of sites 2, 5, and 25 tend to occur with winds from the harbor industrial area - northeast for sites 2 and 5 and southwest for site 25. Thus, the pollutant roses for Baltimore City show the distinct local and areawide effects of industrial development on the TSP concentrations recorded at the sampling sites.

The analyses of land use patterns, urban activities, and pollutant roses, indicate that the high TSP concentrations in Baltimore City are due to industrial development, urban activities such as traffic and space heating,

Figure 16. Pollutant roses at sites surrounding harbor

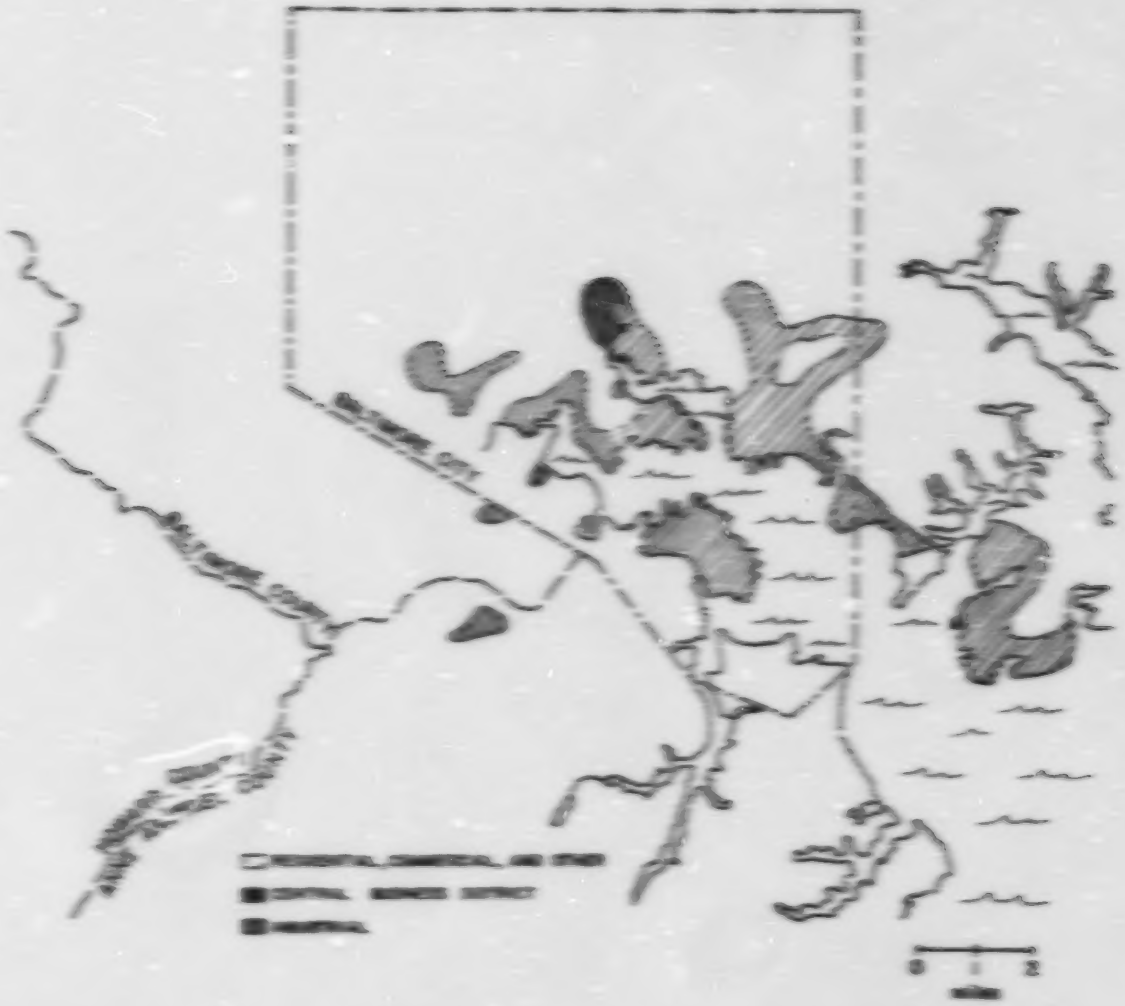

Figure 17. Land use patterns in Baltimore city

and construction activity. These activities also have areawide effects, causing sampling sites near the city to experience high TSP concentrations.

Air Quality Trends

The sampling sites which have been operated for a longer period of time, from 6 to 18 years, have shown overall a decrease in annual mean TSP concentrations despite some fluctuations from year to year. Decreases have ranged from 30 $\mu g/m^3$ at some sites near the city to 70 $\mu g/m^3$ at sites in or near the city. More distant sites have not experienced an apparent decrease in TSP concentrations which appear mainly to be fluctuating over time around some mean. An average decrease of 20 $\mu g/m^3$ has occurred from 1970 to 1974.

A combination of many factors has been causing the improvement in air quality with respect to TSP over the past several years. Fuel usage has been changing in both type and amount of fuel consumed. Coal consumption by homes, industry, and power plants has declined dramatically while natural gas consumption has been increasing. Oil consumption for space heating has decreased but has increased in industry. The recent opening of a nuclear power plant will decrease the power plants' consumption of oil. The fuel shortage and the recent mild winters since 1971 have probably decreased general fuel consumption for space heating. The trend, therefore, has been toward consumption of cleaner fuels and, recently, a decrease in overall fuel consumption by some sectors.

Regulations and enforcement of them have also been factors in the improvement of air quality. The Baltimore AQCR regulations are considered to be stringent, especially the regulation which prohibits visible emissions. Enforcement of the regulations has been rigorous and successful in getting companies under plans for compliance. The result has been decreases in emissions from point sources since 1970.

The trend in TSP concentrations at Fort Howard, site 30, is an extreme example of the effect of these changes - see Figure A3. An open hearth furnace at a nearby steel mill was being operated in the 1960's without controls and was closed in 1971. The steel mill's emissions have been greatly reduced due to the decrease in fuel consumption and controls on emissions. TSP concentrations at site 30 which is about 3 miles southeast of the point source increased from 60 $\mu g/m^3$ in 1961 to over 100 $\mu g/m^3$ in 1965 when sampling was halted. When sampling was started again in 1973, TSP concentrations were down to 50 $\mu g/m^3$.

CONCLUSIONS

Many of the sampling sites in the AQCR, especially in and near Baltimore City, exceeded the national annual and 24-hour standards for TSP in the past due to the high degree of urban and industrial activity. Many sites have experienced decreases in TSP concentrations because of fuel switching, and decreases in fossil fuel consumption; also rigorous enforcement of the stringent regulations and the resulting industrial emissions control. Even after the improvements in air quality with respect to TSP have occurred, half of the sites continue to exceed the annual standards. Particulate emissions from urban activities such as space heating, construction activity, traffic, and fugitive sources have not been controlled and are becoming a more important portion of the urban TSP concentration in Baltimore as other sources are controlled.

APPENDIX A

SUPPLEMENTARY INFORMATION

Table A-1. [illegible]

Station code	Site code	City	County	Address	NAD Easting	NAD Northing	Site characterization	Height (feet)	Active dates: Start	Active dates: Finish	Comments
[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	17	[illegible]	[illegible]	[illegible]			[illegible]		[illegible]		

Table A-1 (continued). [illegible]

[illegible] code	FIPS code	City	County	Address	MP Easting	MP Northing	Site characteristics	Height (feet)	Active filters Short	Active filters Florida	Comments
[illegible]	10	[illegible]	[illegible] City	[illegible]			[illegible]	[illegible]	[illegible]		
[illegible]	15	[illegible]	[illegible] City	[illegible]			[illegible]		[illegible]		
[illegible]	20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	22	[illegible]	[illegible]	[illegible] Library	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	23	[illegible]	[illegible]	[illegible] Hist. Sc. [illegible] Hist.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	24	[illegible]	[illegible]	[illegible] [illegible] [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	25	[illegible]	[illegible]	[illegible] [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	28	[illegible]	[illegible] City	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	
[illegible]	29	[illegible]	[illegible]		[illegible]	[illegible]			[illegible]		
[illegible]	30	[illegible]	[illegible]		[illegible]	[illegible]			[illegible]		
[illegible]	31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]		
[illegible]	32	[illegible]	[illegible]		[illegible]	[illegible]			[illegible]		
[illegible]	33	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]		

Table A-1. [illegible]

Code	Town	Address	Height (feet)	Site characteristics	Land, land use as shown by direction				Site property use ID
					North	East	South	West	
7	[illegible]	[illegible]		CC	No. 32 construction	No. 3 construction	park across street; buildings, major st...	City hall, office park, and interior park	25
9	[illegible]	[illegible]	21	3-8	residential	park	apartments	park	11
10	[illegible]	[illegible]	20	3-8	residential	residential	residential	residential	48
11	[illegible]	[illegible]	20	3-8, 1	hospital, grounds	residential, No. 19 construction	industry, major street	hospital, grounds	25
12	[illegible]	[illegible]	21	3-8	residential, traffic conditioning	residential	street yard, No. 11 construction	residential	8
17	[illegible]	[illegible]	31	1	trees, 20	trees, airport plant	park, trees, factories	single-family, open plain, trees yard	30
19	[illegible]	[illegible]	19	3-8	residential	residential, industry	industry	residential	48

Table A-3. SUMMARY OF REGULATIONS PERTAINING TO PARTICULATES

A. State of Maryland:

Regulation 3 = An Air Pollution Episode System is established providing standards and procedures to be followed whenever air pollution may attain or has attained levels considered injurious to human health.

Regulation 5 = Certain existing installations are required to register to obtain a permit to operate.

Regulation 6 = The Department may require testing of facilities and monitoring of emissions.

Regulation 7 = Malfunctions in installations must be reported.

Regulation 8 = Violators of the Air Quality Control Act are subject to civil penalties. A violator with an approved plan for compliance will not be considered in violation.

Regulation 10 = The Department shall have access to fuel supply records.

Regulation 11 = Certain installations are required to obtain permits to construct and to operate.

B. Baltimore AQCR:

Regulation 1 = No open fires, except certain authorized or allowed open fired, are permitted.

Regulation 2 = Visible emissions from any installation or building (other than water) are prohibited, with certain exceptions.

Regulation 3 = Emission standards and process weight standards for the control of particulate emissions are given for different types of installations. Reasonable precautions shall be taken to prevent particulate matter from materials handling, construction, and other acts from becoming airborne (see Figure A-1).

Regulation 4 = Emission standards for gases and vapors and standards for the sulfur content of fuels are given (see Tables A-4 and A-5).

Table A-1 (continued). SUMMARY OF REGULATIONS PERTAINING TO PARTICULATES

B. Baltimore AQCR (continued):

Regulation 5 - Ambient air quality standards for particulates and other pollutants are set forth. Primary standards for all pollutants are those lowest concentrations attainable by application of all reasonably available methods for reducing pollutant concentrations in the ambient air. Secondary standards are in two categories - the more adverse range and the serious level. When ambient air concentrations of any pollutant are in the more adverse range or exceed the serious level, the application of all necessary methods for reducing such concentrations is required within the shortest reasonable time. For pollutants in the more serious range, such reasonable time shall not exceed 7 years; for pollutants exceeding the serious level, the time shall not exceed 3 years. In situations of time and place where an air pollutant does not exceed the secondary standards, all necessary methods are required to minimize increases of that pollutant in the ambient air so that the secondary standards shall not be exceeded in the future.

Regulation 6 - No installation shall be operated so that a nuisance or air pollution is created.

Table A-4. EMISSION STANDARDS AND DUST COLLECTION PERFORMANCE STANDARDS FOR FUEL BURNING INSTALLATIONS

Installation description	Maximum rated heat input in 10^6 Btu per hour performance	Maximum allowable emission of particulate matter gr/SCFD	Maximum allowable emission; Shell Bacharach smoke spot test number	Require collection efficiency of dust collector
Residual oil burning	< 10	0.05	4	50% or more
	10 - 50	0.25	4	60% or more
	51 - 200	0.02	4	70% or more
Residual oil burning - existing and modified installations	> 200	0.02	4	70% or more
Residual oil burning - new fuel burning equipment	> 200	0.01	4	90% or more
Distillate oil burning	All sizes	No requirement	3	No requirement
Solid fuel burning	≤ 200	0.05	No requirement	90% or more
	> 200	0.03	No requirement	99% or more

Table A-5. SULFUR CONTENT OF FUELS

	Upper limits of sulfur content by weight
Distillate fuel oils	≤ 0.3%
Residual fuel oils	≤ 0.5%
Process gases used as fuel	≤ 0.3%
All fuels	≤ 1.0%

Table A-6. MARYLAND STATE AIR QUALITY STANDARDS FOR PARTICULATE MATTER

Pollutant	Measure	Times values may be exceeded per unit time	More adverse range		Serious Level
			Lower limit	Upper limit	
Suspended particulate	Annual arithmetic average		65 $\mu g/m^3$	75	75
	Daily average	Once per year	150 $\mu g/m^3$	160	160
Dustfall	Annual arithmetic average	Values not to be exceeded	0.35 mg/ cm^2/month	0.50	0.50

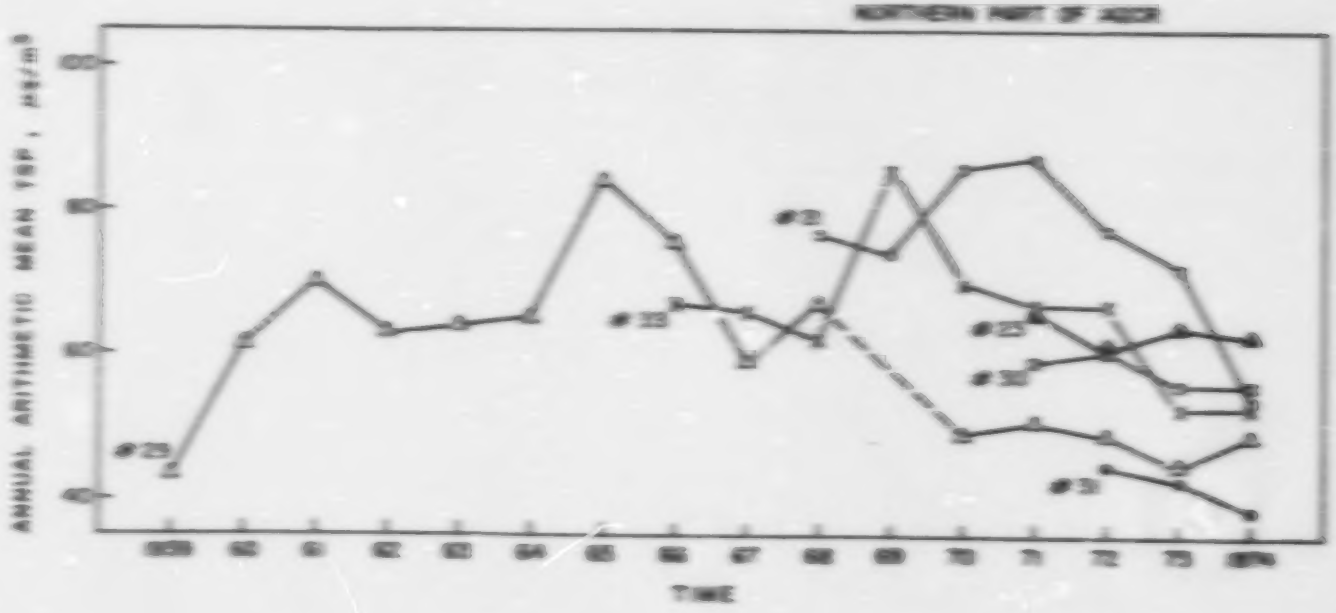

Figure A-L. TSP trends at sites in the northern part of the AQCR

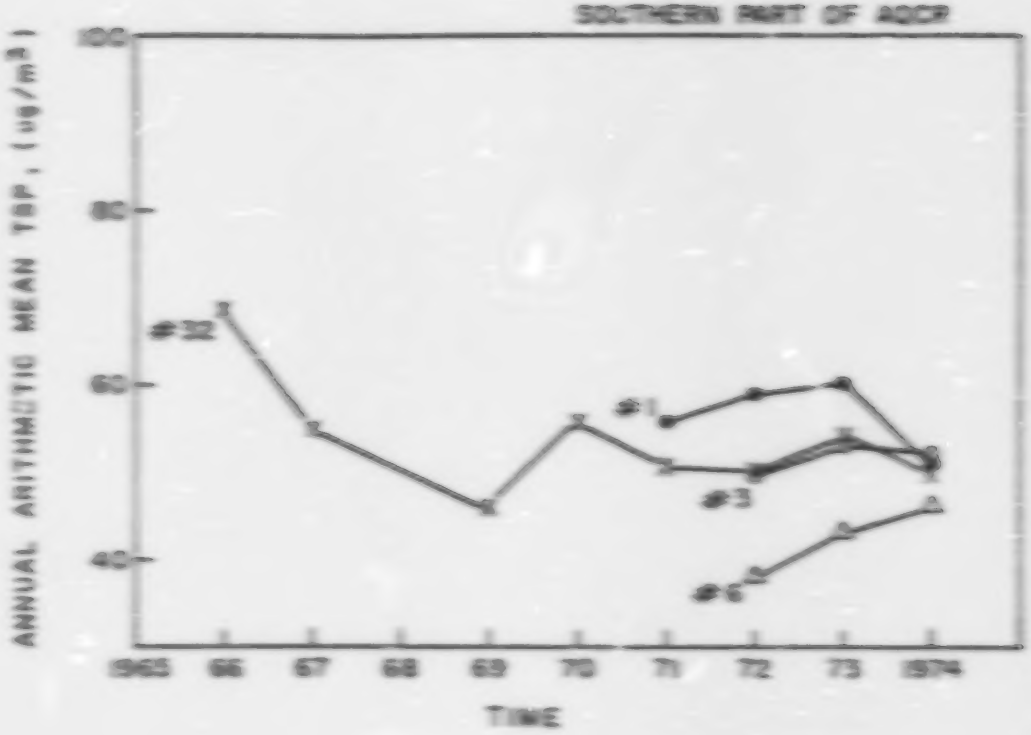

Figure 4-2. TSP trends at sites in the southern part of the AQCR

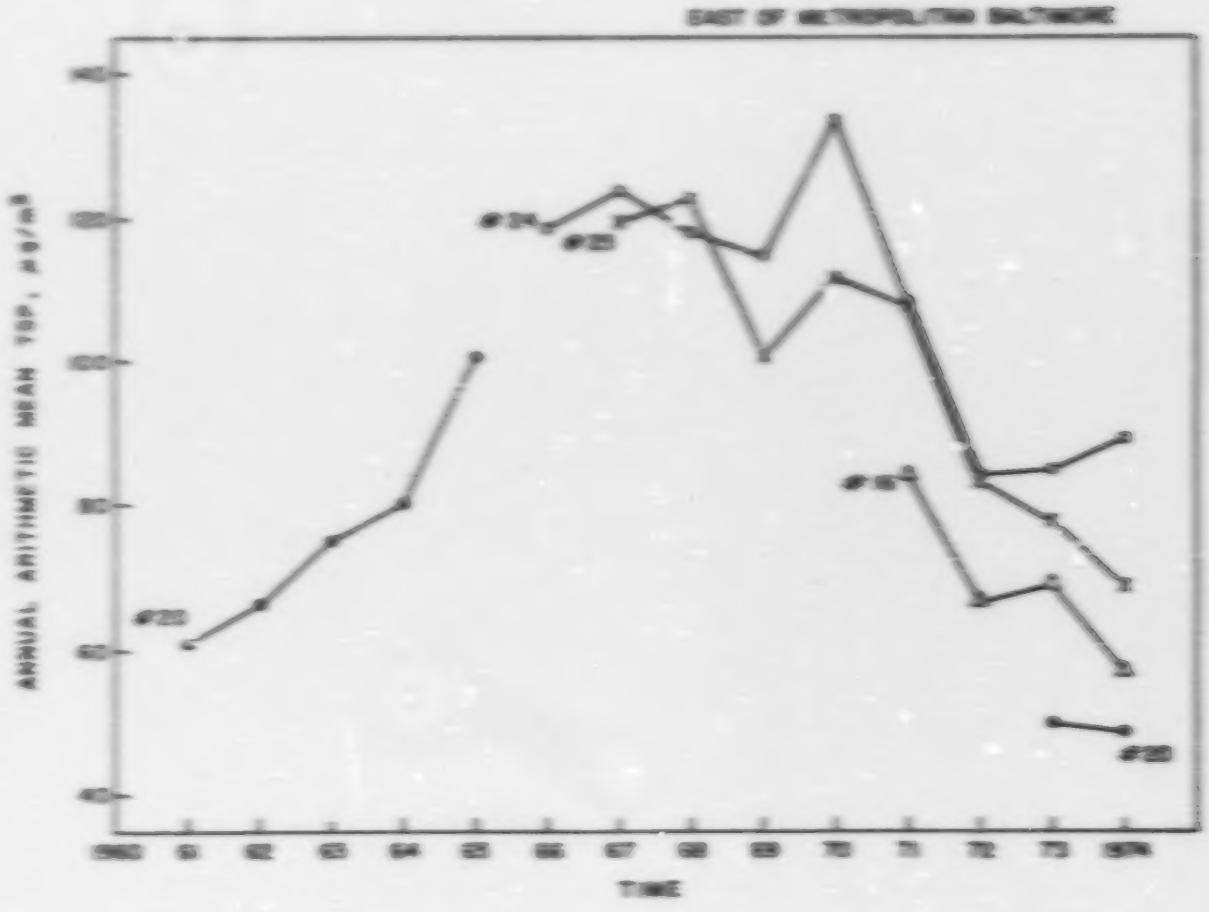

Figure A-1. TSP trends at sites east of Baltimore city

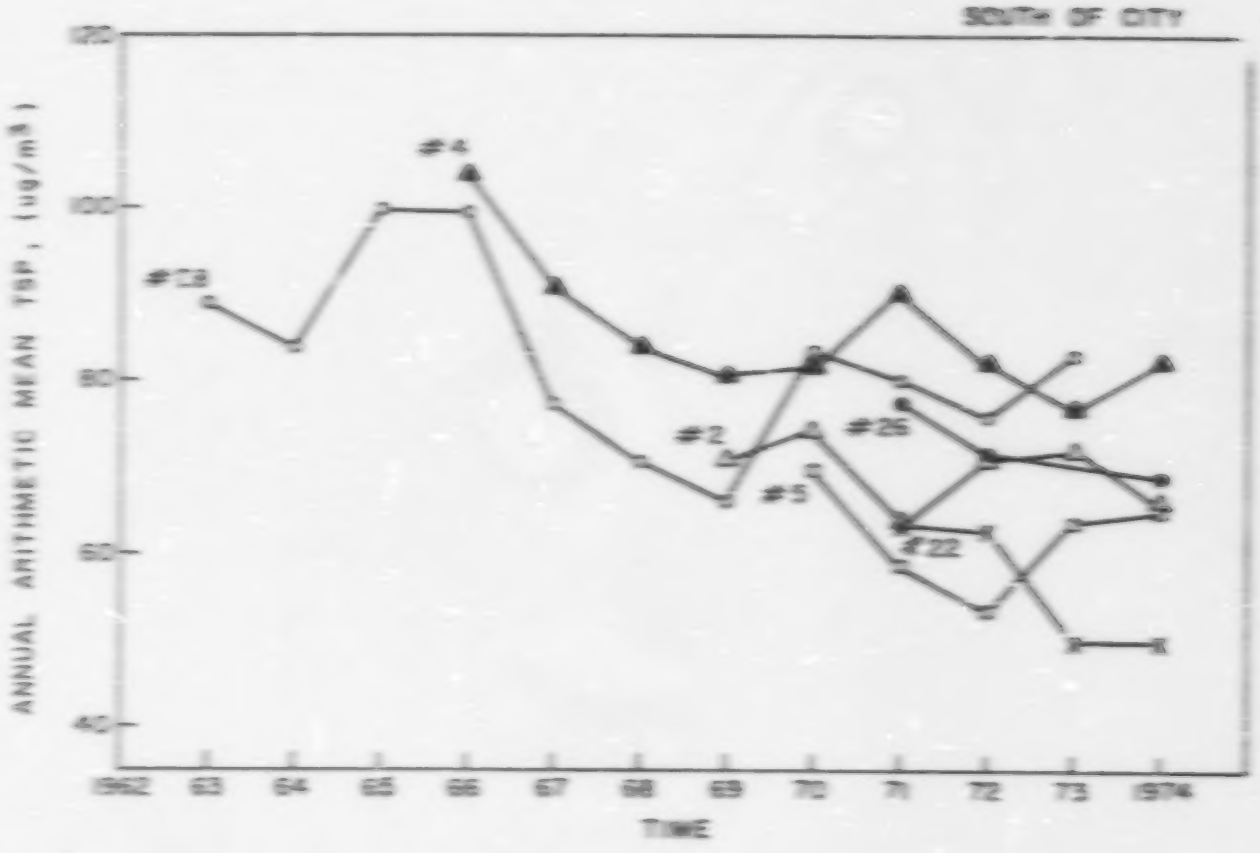

Figure 4-4. TSP trends at sites south of Baltimore city

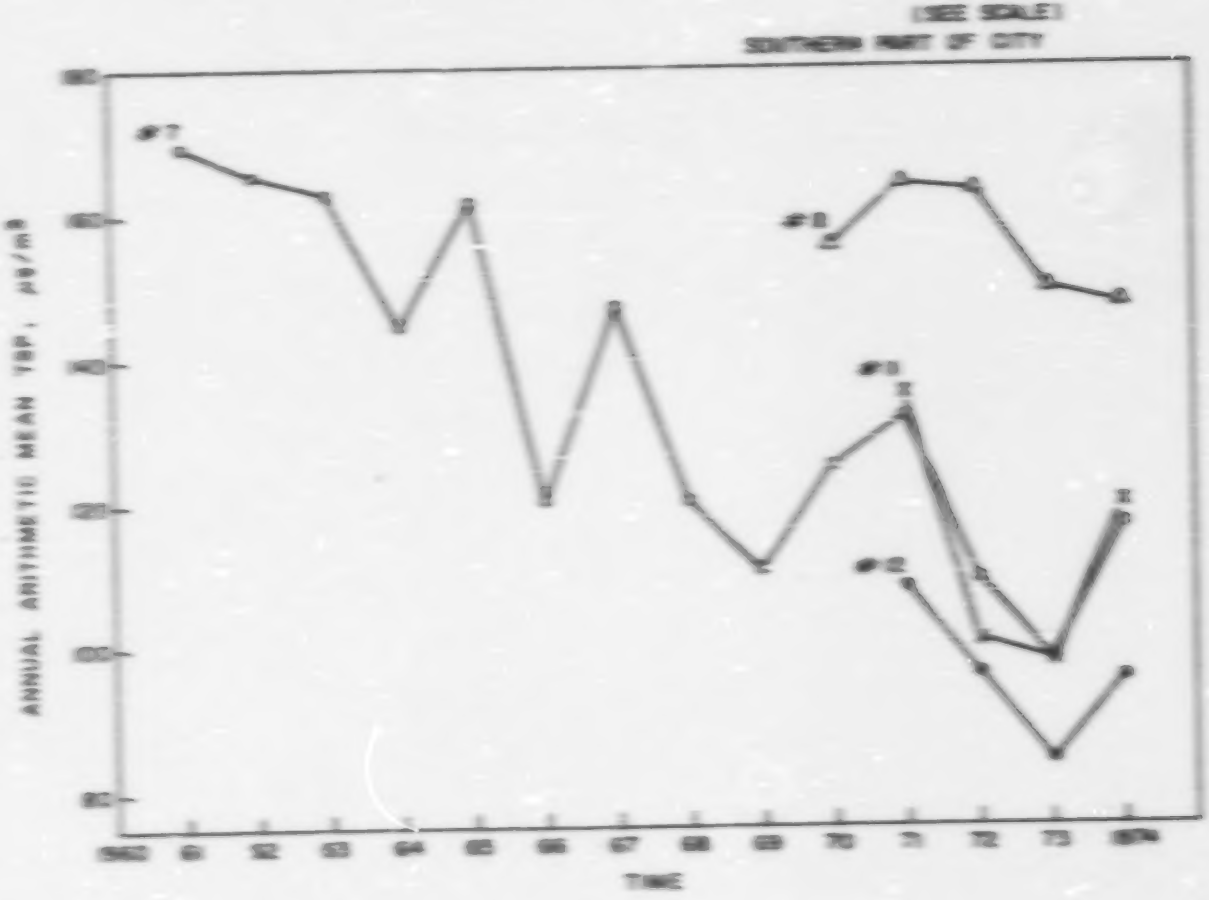

Figure A-5. TSP trends at sites in the southern part of Baltimore city

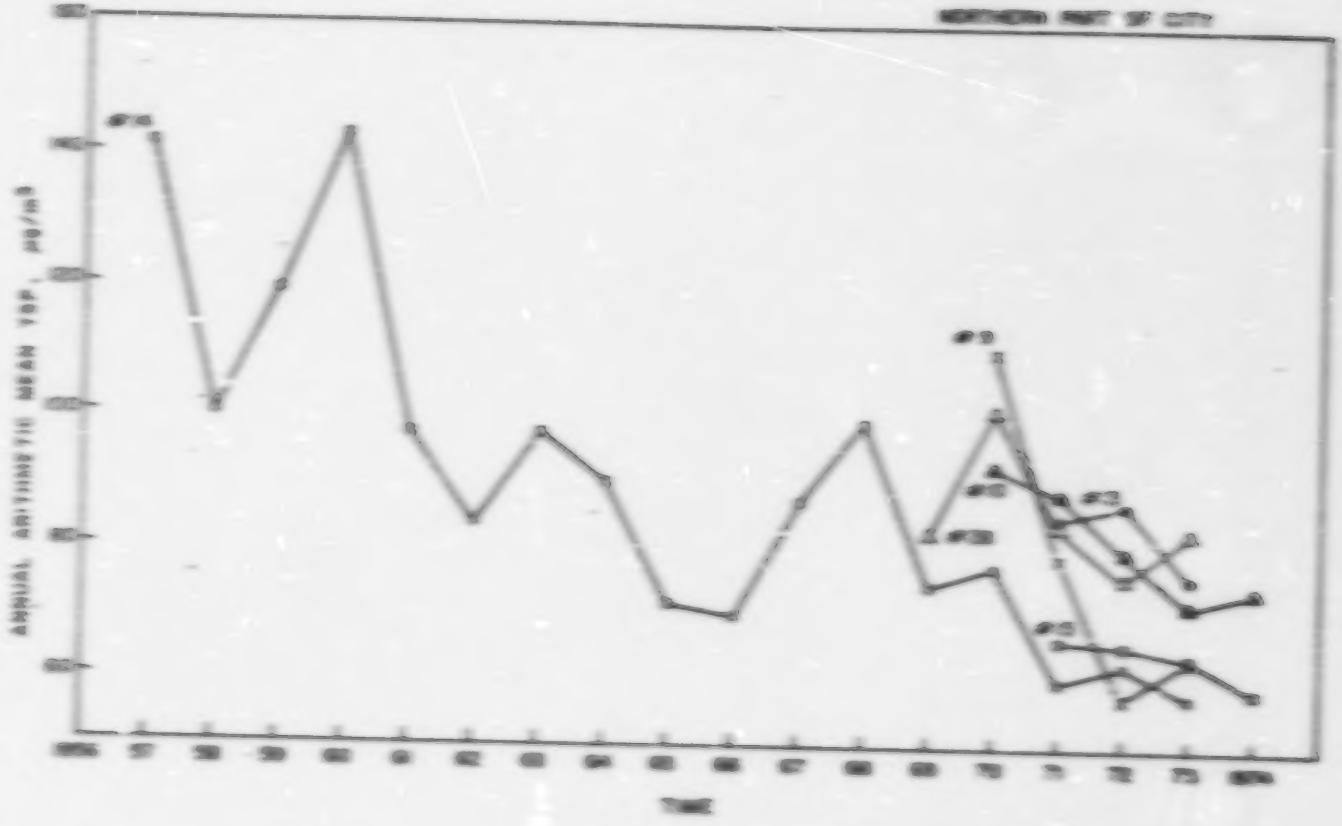

Figure A-6. TSP trends at sites in the northern part of Baltimore city

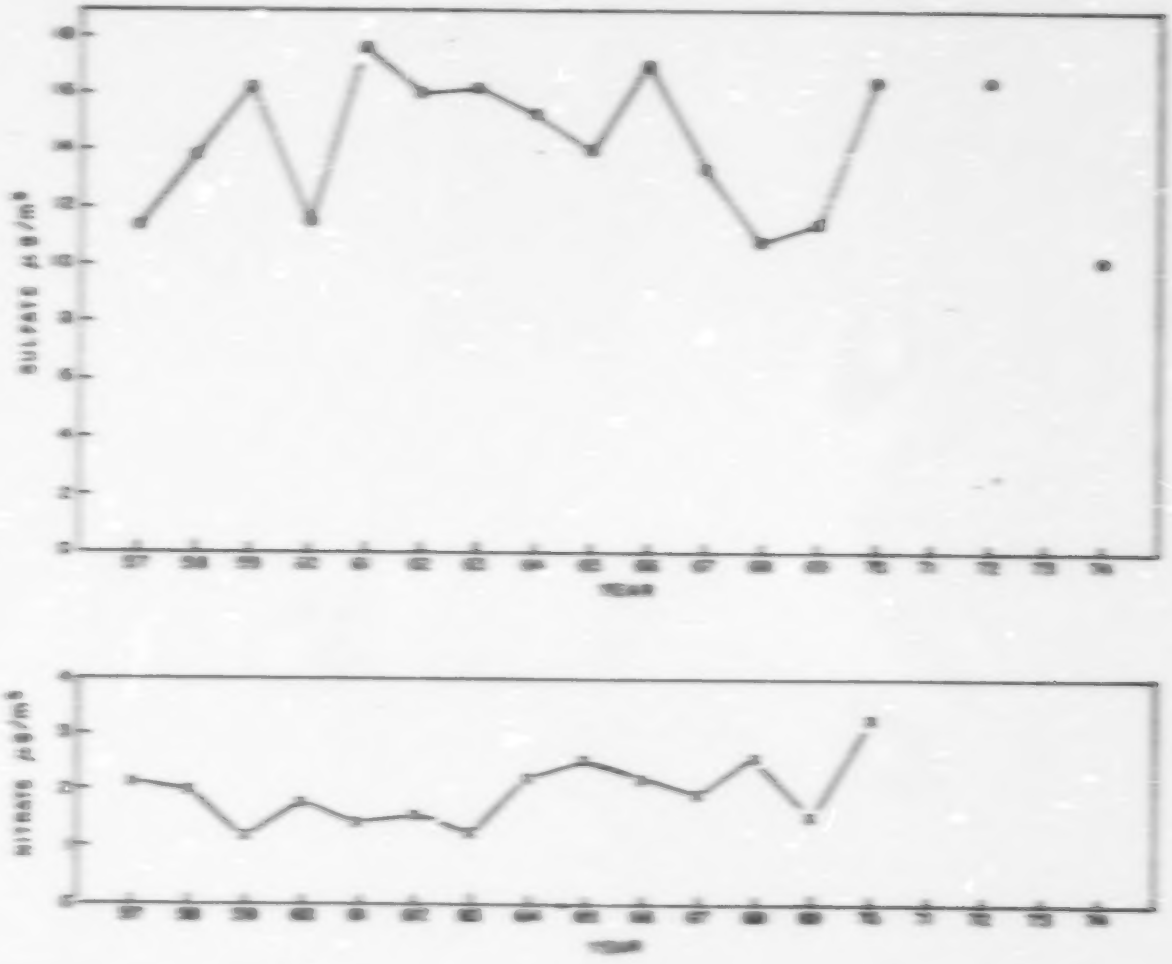

Figure A-7. Annual means for sulfate and nitrate at the NASN station at Fire Department Headquarters

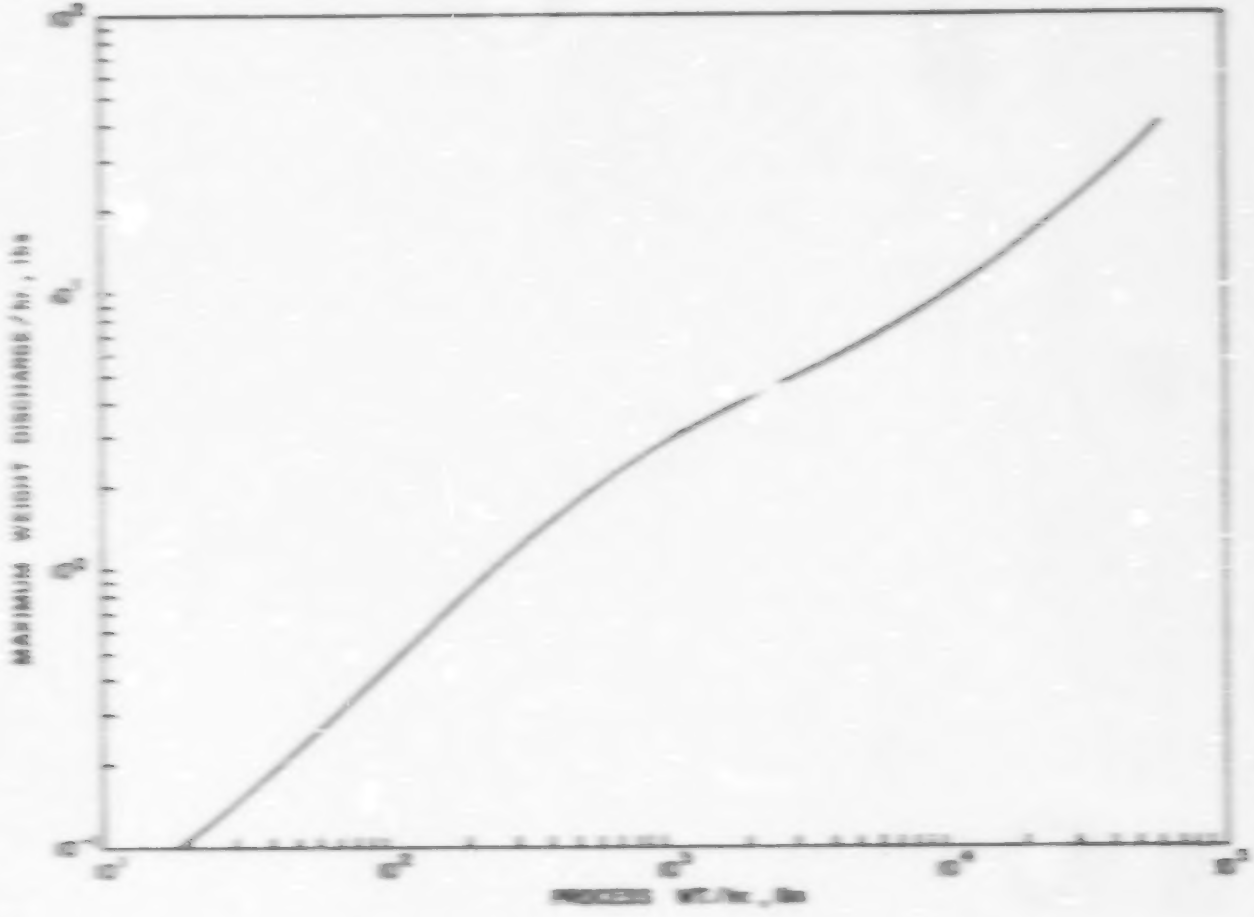

Figure A-6. Process weight regulation for installations other than fuel-burning, incinerators, or grain-drying

APPENDIX B

PARTICLE CHARACTERIZATION

For most of the study cities members of the GCA study team acquired hi-vol filters from the 1974 filter banks of the cognizant local agencies. In addition, several filter samples for 1974 and selected earlier years were obtained from state and federal filter banks. Although some filters underwent chemical and/or detailed physical analysis, the principal purpose of obtaining filters was to utilize optical microscopy to identify each of the constituents that comprised more than 5 percent of the particulate mass. The selected filters, which were representative of several different site types and TSP levels within each study area, were returned to a clean room at GCA/Technology Division and carefully inspected for artifacts and evidence of sampler or filter malfunctions.

Each filter was then assigned a randomly generated five digit number which served as the only identifier for the filter sample so that each analyst had no information concerning the city, site, TSP loading or probable local sources associated with the sample. Furthermore, the use of two laboratories for the microscopy, coupled with the randomly generated identifying numbers, permitted a fairly comprehensive quality control program in the form of blind replicate analyses. Since both laboratories utilized more than one analyst, these procedures resulted in as many as four microscopists observing samples from the same filter and, in some cases, the same analyst examining replicate samples from the same filter as many as three times.

The results of this quality control effort, which are presented in Volumes I and II, warn against relying very heavily on the results of any

one filter analysis. However, the random match-up between analyst and filter sample should minimize systematic bias in composited results.

Forty-two filters from eight sites were selected for analysis in Baltimore and Table B-1 summarizes the meteorological data for the selected sampling days. To gain some insight into the contribution of secondary particulate, much of which is too small to be observed by the microscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table B-2. The results for each of the filters submitted for routine analysis from all sites except the NASN site are presented in Table B-3. The results for the filters at each site have been averaged to give a composite of the particulate composition as shown in Table B-4. Seven filters underwent replicate analyses, and the results of this task are presented in Table B-5.

Baltimore was one of three study cities selected for particulate trends analysis. To accomplish this task, two to four filters for each of the calendar years 1964, 1970, 1971, 1973 and 1974 were selected from the NASN sampling site for microscopic analysis. The results of each filter analysis are presented in Table B-6 and a composite summary for each year is presented in Table B-7. Several changes in the makeup of the particulate have apparently taken place, especially between 1964 and 1970. During that interval the percent contribution by combustion products decreased by more than a factor of two. This decrease, from 47 percent to 22 percent of the observed particulate, was matched, however, by an equally impressive increase in the percent contribution by minerals. Of course, when describing the amount of material in percents, a decrease in one constituent must be matched by an increase in another constituent(s) because the total must equal 100 percent. However, if the microscopy results are a reliable indication of the make-up of all the particulate collected on the hi-vol filters, then the weighted average concentration of combustion products on the filters analysed dropped from 94 $\mu g/m^3$ in 1964

to 44 $\mu g/m^3$ in 1970. The corresponding increase in minerals was from 134 $\mu g/m^3$ in 1964 to 193 $\mu g/m^3$ in 1970.

The makeup of the particulate at the NASN site since 1970 has shown year to year fluctuations, but a continued downward trend in combustion products is indicated. This decrease in the combustion products apparently has not been accompanied by an increase in the percent minerals. The amount of rubber detected on filter samples from this site, however, has risen sharply. In the 3 most recent years of record rubber accounted for nearly 15 percent of the particulate at the NASN site. This is in sharp contrast to the composite results of analyses of non-NASN sites in Baltimore for 1974, as shown in Table B-8. A city wide average rubber content of only 2 percent is indicated, which is as low as any of the 14 study cities. Interestingly, the non-NASN site with the highest reported levels of rubber was site seven which is located on the same roof as the NASN hi-vol. The average rubber content for the four filters analysed from that site was 7 percent, but ranged as high as 26 percent on August 27, 1974. That was also a NASN sampling day and a sample of the NASN filter was also analysed microscopically. The results, compiled by two separate analysts, compare reasonably well, especially for the percent combustion products. Oddly, the NASN sample was reported to have less rubber than the sample from the local agency site.

The total amount of mineral material reported at the NASN site for 1974 is in excellent agreement with the composite shown in Table B-8 for the non-NASN sites. Even the individual constituents of quartz, calcite, feldspars and hematite are in good agreement. The amount of mineral material reported for Baltimore is very typical of the other study cities, ranking sixth highest. In terms of combustion products, Baltimore is seventh out of the 14 study sites and so is quite typical in that respect as well.

One of the filters that had undergone routine optical microscopic analysis was also submitted for detailed physical examination. The results of this task are presented in Table B-9. The Maryland Bureau of Air Quality Control takes portions of hi-vol filters and runs chemical analyses on the monthly composite samples. The results of analyses for lead and benzo(a) pyrene are presented in Tables B-10 and B-11, respectively, for six Baltimore City sites.

Table B-1. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (FRIENDSHIP INTERNATIONAL AIRPORT, BALTIMORE)

Date	Precipitation, in.		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
7/19/64						
10/01/64						
10/27/64						
4/09/70	0.01	0	12.7	10.4	250, 240, 240, 250 200, 290, 290, 300	250
5/27/70	0	0.03	11.2	10.1	290, 290, 310, 280 290, 330, 350, 350	310
7/06/70	0.42	0	7.1	4.4	200, 200, 160, 270 220, 140, 330, 240	230
8/14/70	t	0	6.6	2.8	260, 0, 210, 160 160, 180, 260, 310	280
1/29/71	t	t	8.3	7.6	260, 170, 160, 210 220, 210, 190, 180	200
2/11/71	0	0	4.8	4.6	0, 0, 0, 170 130, 160, 160, 170	150
5/06/71	0	0	15.9	15.3	270, 260, 270, 290 270, 280, 280, 250	270
7/29/71	0	0	4.5	4.0	80, 0, 70, 60 120, 120, 170, 100	100
7/27/73	0	0.02	9.2	7.8	190, 210, 250, 230 260, 280, 200, 190	230
9/01/73	0	0	4.2	3.7	0, 250, 0, 240 160, 260, 240, 260	250

Table B-1 (continued). METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (FRIENDSHIP INTERNATIONAL AIRPORT, BALTIMORE)

Date	Precipitation, in		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	1-hour observation	Resultant
1/05/74	0	0.15	4.9	2.2	290, 350, 160, 70 70, 140, 0, 0	30
1/17/74	0	0	8.9	7.8	280, 20, 350, 360 10, 30, 40, 60	10
2/12/74	0	t	6.5	5.0	190, 250, 260, 270 270, 270, 140, 0	250
2/28/74	t	0	8.5	7.0	190, 0, 0, 200 160, 220, 260, 180	210
8/15/74	0	0.12	6.9	4.3	270, 40, 20, 60 80, 100, 140, 140	60
8/27/74	0	1.73	9.3	6.8	210, 230, 0, 150 220, 210, 180, 180	200
9/17/74	t	0	5.6	4.9	0, 60, 160, 200 190, 210, 200, 180	190
9/26/74	0	0	6.8	6.1	250, 280, 260, 270 270, 270, 170, 250	260

Note: 0 = Calm
t = Trace

Table B-2. ANNUAL AVERAGE CONCENTRATIONS OF SULFATE AND NITRATE IONS AT THE BALTIMORE, MARYLAND, BASN SITE NO. 210120001, $\mu g/m^3$

Year	Sulfate		Nitrate	
	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	16.52	15.07	3.05	2.59
1973	12.71	11.69	3.17	2.87
1974	11.43	10.26	3.69	3.35

Table B-3a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BALTIMORE AND VICINITY (FIRE DEPT. BQ. – NO. 7)

Date	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TSP ($\mu g/m^3$)	227			148			92[a]			231		
Constituent	Geom. mean, nanog.	Conc. range, ng.	Avg. conc., ng.	Geom. mean, nanog.	Conc. range, ng.	Avg. conc., ng.	Geom. mean, nanog.	Conc. range, ng.	Avg. conc., ng.	Geom. mean, nanog.	Conc. range, ng.	Avg. conc., ng.
[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 9-3b. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BALTIMORE AND VICINITY
(POST SHOT – NO. 17)

Area	1 January 1954			27 January 1954			28 February 1954			23 August 1954			27 August 1954			29 September 1954		
Time (μc/m²)	40			110			160			90			74			12[a]		
Constituent	Quantities, micrograms	Size range, μ	Avg. size, μ	Quantities, micrograms	Size range, μ	Avg. size, μ	Quantities, micrograms	Size range, μ	Avg. size, μ	Quantities, micrograms	Size range, μ	Avg. size, μ	Quantities, micrograms	Size range, μ	Avg. size, μ	Quantities, micrograms	Size range, μ	Avg. size, μ
Beryllium	[illegible]			[illegible]			[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]			[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]				[illegible]		
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[illegible]	[illegible]			[illegible]			[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]																		
[illegible]							[illegible]											
[illegible]																		
[illegible]																		
[illegible]																		
[illegible]	[illegible]			[illegible]			[illegible]			[illegible]			[illegible]			[illegible]	[illegible]	[illegible]
[illegible]																		
[illegible]																		

[a] [illegible]

Table B-3c. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BALTIMORE AND VICINITY (N. E. POLICE – NO. 9, FIRE ENGINE CO. 10 – NO. 8, AND PATAPSCO – NO. 19)

Site	N. E. Police – No. 9									Fire Engine Co. 10 – No. 8						Patapsco – No. 19		
Date	24 February 1971			26 February 1971			17 September 1971			28 February 1971			29 September 1971			25 February 1971		
Time (L.S.T.)	12h			12h			9h			24h			24h			24h		
Properties	Number (10³), particles	Dust weight, μg	Mean mass, μg	Number (10³), particles	Dust weight, μg	Mean mass, μg	Number (10³), particles	Dust weight, μg	Mean mass, μg	Number (10³), particles	Dust weight, μg	Mean mass, μg	Number (10³), particles	Dust weight, μg	Mean mass, μg	Number (10³), particles	Dust weight, μg	Mean mass, μg
[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]																	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]																		
[illegible]																		
[illegible]																	

Table B-34. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BALTIMORE AND VICINITY (FINE ENGINE CO. 22 – NO. 18)

Item	5 January 1954			17 January 1954			28 February 1954			25 August 1954			27 August 1954		
TSP ($\mu g/m^3$)	30			72			241			224			84		
Component	Quantity, particle	Size range, μ	Avg. size, μ	Quantity, particle	Size range, μ	Avg. size, μ	Quantity, particle	Size range, μ	Avg. size, μ	Quantity, particle	Size range, μ	Avg. size, μ	Quantity, particle	Size range, μ	Avg. size, μ
[illegible]	[illegible]			[illegible]			[illegible]	2-42	4	[illegible]			[illegible]	2-175	22
[illegible]	1	2-32	3	3	2-128	7	4+			2+	2-32	3	4+		
[illegible]	2+	2-42	5	2	2-48	3	2			2+	2-25	3	2		
[illegible]										1+					
[illegible]	4	2-10	4.5	7+	2-32	6.5	5+			4	2-128	6.5	4		
[illegible]															
[illegible]	[illegible]			[illegible]			[illegible]	2-48	7	[illegible]			[illegible]	2-90	6
[illegible]															
[illegible]	1	2-200	6.5	5+	2-1,024	6.5				1					
[illegible]	2+						2+			2+					
[illegible]													2+		
[illegible]													1		
[illegible]							5+								
[illegible]															
[illegible]															
[illegible]															
[illegible]	[illegible]			[illegible]			[illegible]	4-24	10	[illegible]			[illegible]		
[illegible]															
[illegible]															
[illegible]															
[illegible]							1								
[illegible]															
[illegible]	[illegible]			[illegible]			[illegible]			[illegible]			111	10-420	42
[illegible]													1		
[illegible]															

Table B-3a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BALTIMORE AND VICINITY (LANGBORNE – NO. 26)

Item	5 January 1954			17 January 1954			28 February 1954			23 August 1954			27 August 1954			1 September 1954		
CST (GMT)	07			01			07			01			07			07		
Station	Beam attn. coeff., m^{-1}	Size range, μ	Avg. size, μ	Beam attn. coeff., m^{-1}	Size range, μ	Avg. size, μ	Beam attn. coeff., m^{-1}	Size range, μ	Avg. size, μ	Beam attn. coeff., m^{-1}	Size range, μ	Avg. size, μ	Beam attn. coeff., m^{-1}	Size range, μ	Avg. size, μ	Beam attn. coeff., m^{-1}	Size range, μ	Avg. size, μ
[illegible]	[illegible]			[illegible]			[illegible]			[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Table B-5. RESULTS OF REPLICATE ANALYSES OF BALTIMORE FILTERS

Site	Pine Region Co. [illegible] — No. 28														Jonestown — No. 29				Pine Manor, Inc. No. 7	
Date	27 January [illegible]				28 February [illegible]					13 August [illegible]		27 August [illegible]			27 January [illegible]		28 February [illegible]		28 February [illegible]	
Filter No.	1		72				241			179			91		93		42		144	
Laboratory No.	14	15	1	13	6	4	8	5	7	9	11	1	4	5	1	1	5	1	1	6
Analyst	1	2	1	1	1	2	1	1	2	1	2	1	2	1	1	1	1	2	1	2
Concentration																				
Aluminum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Antimony	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Arsenic	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Barium	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Beryllium	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Boron	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cadmium	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Calcium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chromium																				
Cobalt	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Copper	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Iron	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lead	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Magnesium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Manganese	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Molybdenum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nickel	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Potassium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Silicon	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Silver	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sodium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Strontium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Titanium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Vanadium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Zinc	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Zirconium	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tare or blank	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sulfate	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Table 3-4a. RESULTS OF FILTER ANALYSES FOR THORIUM AT MAIN SITE NO. [illegible]
IN BALTIMORE (1964 AND 1970)

Item	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table B-4b. RESULTS OF FILTER ANALYSES FOR TRENDS AT BASE SITE NO. 210730121 IN BALTIMORE (1970, 1971, AND 1973)

Date	4 August 1971			29 January 1971			2 February 1971			4 May 1971			29 March 1973			23 July 1973		
Time (L.S.T.)	1100			1045			1145			1030			1145			1030		
Determinate	Flow rate, m³/min	Flow rate, ft³/min	Vol. sampled, m³	Sample conc., mg/m³	Blank corr., mg/m³	Avg. conc., µg/m³	Sample conc., mg/m³	Blank corr., mg/m³	Avg. conc., µg/m³	Sample conc., mg/m³	Blank corr., mg/m³	Avg. conc., µg/m³	Sample conc., mg/m³	Blank corr., mg/m³	Avg. conc., µg/m³	Sample conc., mg/m³	Blank corr., mg/m³	Avg. conc., µg/m³
Particulate	1.84	65.0	1.7	1.1			1.4			1.4	-0.01	1.0	1.4			1.4		
Lead (Pb)	1.84			1.1	-0.0077	0	1.4	-0.0007	0	1.4			1.4	-0.0008	1	1.4	-0.0008	1
Cadmium (Cd)	1.84			1.1	-0.001	1	1.4	-0.001	1	1.4			1.4	-0.001	1	1.4	-0.001	1
Nickel (Ni)				1.1			1.4			1.4						1.4		
Iron (Fe)	1.84			1.1	-0.001	0.9	1.4	-0.001	-0.7	1.4			1.4	-0.001	0.7	1.4	-0.001	0.7
Sulfate (SO₄)	1.84			1.1			1.4			1.4	-0.04	3	1.4			1.4		
Nitrate (NO₃)																		
Nitrite																		
Ammonia				1.1	-0.001	0.9	1.4	-0.001					1.4	-0.001	0.7	1.4	-0.001	0.7
Chloride	1.84									1.4								
Fluoride				1.1			1.4			1.4								
Phosphate																		
Organic carbon																		
Hydrocarbons																		
Benzene (C₆H₆)	1.84			1.1			1.4			1.4			1.4			1.4		
Toluene																		
Xylene																		
Ethane																		
Propane																		
Other hydrocarbons																		
Carbon monoxide	1.84			1.1			1.4			1.4	-0.1	0.9	1.4			1.4		
Ozone or oxidant																		
Sulfur dioxide				1.1						1.4			1.4	-0.001	0.7	1.4	-0.001	0.7

Table B-6c. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 210120001 IN BALTIMORE (1973 AND 1974)

Date	1 September 1973			13 August 1974			27 August 1975		
TSP ($\mu g/m^3$)	113			102			59		
Component	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(74)			(8)			(84)		
Quartz	39	<1-100	5	3	1-50	5	3	<1-60	
Calcite	8	<1-80	5	3	<1-10	5	2	<1-60	
Feldspars				1			1		
Hematite	14	<1-100	0.5	14	<1-50	0.5	1	<1-10	0.5
Mica									
Combustion Products	(1)			(1)			(2)		
Soot:									
Oil	1	<1-300	0.5	1	<1-100	0.5	10	<1-120	0.5
Coal									
Glass							1		
Fly ash									
Incinerator fly ash									
Burned wood									
Burned paper									
Magnetite									
Biological Material	(99)			(99)			(98)		
Pollen									
Spores									
Algae									
Starch									
Misc. plant tissue									
Miscellaneous	(14)			(1)			(14)		
Type of Glass Bubble	14	<1-300	3	1	<1-130	30	14	<1-130	30

Table B-7. COMPOSITE SUMMARY OF FILTER ANALYSES FOR NASH SITES IN BALTIMORE AND VICINITY (BY YEAR)

Year	1970		1971		1972		1973		1974	
No. of filters	4		4		3		3		3	
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent	
Components	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
Minerals	(32)	25-35	(27)	18-35	(61)	59-77	(15)	11-15	(23)	20-25
Quartz	11	8-13	11	11-11	21	18-25	12	10-15	10	10
Calcite	5	1-7	6	0-13	19	10-29	01	00-10	05	00-10
Feldspars	2	0-5	2	0-8	5	3-6	1	1-5	5	5
Hematite	13	0-32	13	5-35	13	10-15	12	10-15	13	10-15
Mica	<1	0-1			5	0-10	<1	0-1		
Other			3	0-8						
Combustion Products	(67)	25-75	(22)	13-50	(31)	15-61	(11)	10-13	(15)	10-21
Soot:										
Oil	31	0-75			21	3-35	9	<1-10	11	7-15
Coal	1	0-8			1	0-3	<1	0-1	1	1-3
Coke	7	0-24	16	12-25	3	0-9				
Glass	1	<1-8	1	1-1	6	5-10	1	1	1	1-1
Fly ash										
Incinerator fly ash										
Burned wood	1	0-1								
Burned rice										
Magnetite										
Other			1	0-10						
Biological Material	(1)	0-1	1	0-1	(-1)	<1-1	(-1)		(-1)	<1-1
Pollen			<1		<1		<1		<1	
Spores	<1		<1		<1		<1		<1	
Kapok			<1	0-1	<1		<1		<1	
Starch	1	0-1	<1	0-1	<1		<1		<1	
Misc. plant fibers	<1	0-1			<1	<1-1	<1		<1	<1-1
Other			1	0-1						
Miscellaneous	(-1)		(-1)		(-1)	<1-10	(<1)	11	(11)	10-15
Iron or steel	<1		<1		<1		<1		<1	
Rubber					0	<1-10	11	11	11	10-15

Table 5-8. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN BALTIMORE

No. of filters	27[a]	
	Quantity, percent	
Components	Average	Range
Minerals	(59)	38-88
Quartz	31	10-50
Calcite	18	2-51
Feldspars	3	0-6
Hematite	15	2-46
Mica	<1	
Other	8	0-46
Combustion products	(8)	1-61
Soot:		
Oil	0	0-60
Coal	5	0-52
Misc. soot	0	0-50
Glassy fly ash	0	0-42
Incinerator fly ash	<1	
Burned wood	<1	
Burned paper	<1	
Magnetite		
Carbon black		
Other	1	0-12
Biological material	(3)	<1-11
Pollen	<1	
Spores	<1	
Paper	<1	
Starch	1	0-8
Misc. plant tissue	2	0-10
Leaf trichomes		
Miscellaneous	(3)	0-26
Iron or steel	1	0-10
Rubber	2	0-26
Other		

[a]Includes filter analyses of BACH site samples

Table B-9. DETAILED PHYSICAL EXAMINATION: FIRE ENGINE CO. 32, BALTIMORE, JANUARY 17, 1974

A. Quartz - confirmed by refractive indices and (+) uniaxial interference figure. EDXRA shows only silicon and traces of aluminum.

B. Calcite - Confirmed by refractive indices, and (-) uniaxial interference figure. Carbonate confirmed microchemically by evolution of CO_2 gas. EDXRA shows only calcium. Some samples show trace of magnesium indicating some particles are dolomite, $CaMg(CO_3)_2$.

C. Hematite - confirmed by high refractive indices, birefringence and deep red color. EDXRA shows only iron.

D. Oil soot - oil soot confirmed by brittleness, morphology of large pieces and EDXRA which showed aluminum, silicon, calcium, sulfur, iron and vanadium. The major constituent was carbon. The vanadium principally distinguishes this sample chemically from fine coal soot.

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